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CONTRACT TRIAL OF THE UNITED STATES SEAGOING BATTLESHIP *KEARSARGE*.

BY LIEUTENANT CLAUDE B. PRICE, U. S. NAVY.

The *Kearsarge* is a twin-screw, armored, seagoing battleship, and was built by the Newport News Shipbuilding and Dry Dock Company, of Newport News, Va. The Navy Department furnished the general plans and specifications for hull and machinery to the contractors and builders, and the latter developed the general designs into exact details, together with the piping systems and location of the auxiliary machinery, submitting their drawings for approval to the bureaus concerned before work was begun. The contract was signed January 2, 1896, the price being $2,250,000, and the time allowed for completion three years. The price stated above does not include the armor (exclusive of that required in the construction of the protective deck), the armor bolts, the ordnance, the ordnance outfit, and certain articles, as anchors and chains, supplied by the Government, but does include the fitting and installation of the above. The speed guarantee was sixteen knots per hour, to be maintained successfully for four consecutive hours, during which

period the air pressure in the fire rooms was not to exceed an average of one inch of water; the vessel to be weighted to a mean draught of twenty-three feet six inches. No premium for speed in excess of that required by the contract was provided for, but a penalty was inflicted at the rate of $100,000 per knot in case the speed developed should fall below sixteen knots, but if it should fall below fifteen knots, it was optional with the Secretary of the Navy to reject the vessel or accept her at a reduced price. The weight of the machinery was limited to 1,100 tons, which weight included main engines, boilers and appurtenances, distilling apparatus, stores, spare parts, heating apparatus, tools in workshop, and water in boilers, condensers, pumps, pipes and stern tubes, but did not include turret machinery, capstan, windlass, steering gear or winches. The penalty for over weight was $500 per ton up to 5 per cent., beyond which an additional $10,000 was to be attached.

HULL.

Length between perpendiculars, feet	368
on L.W.L., feet and inches	368- 1½
over all (including rudder), feet and inches	375- 4½
Beam, extreme, feet and inches	72-2½
at L.W.L., feet and inches	72-2½
Ratio of length to beam	5.20
Depth, from top of main-deck beams at side to bottom of frames at M.P., feet and inches	33- 8
Height of superstructure above main-deck beams to top of hammock berthing on upper deck, feet and inches	12- 0
Draught, normal, forward, feet and inches	23- 7⅜
aft, feet and inches	23- 7⅜
mean, feet and inches	23- 7⅜
Displacement, corresponding to normal draught, tons	11,600
per inch, at L.W.L., tons	47.74
Area of immersed midship section to L.W.L., square feet	1,620
L.W.L. plane, square feet	20,070
Center of gravity of L.W.L. plane, aft of M.P., feet and inches	1- 9
buoyancy above bottom of keel, feet and inches	12- 9⅝
forward of M.P., feet and inches	1- 0½
gravity above bottom of keel, feet and inches	25- 0½
Transverse metacenter above center of buoyancy, feet and inches	16-11¼
Longitudinal metacenter above center of buoyancy, feet and inches	367- 0
Coefficient of fineness on extreme dimensions	.643
of midship section	.957

Coefficient of fineness of L.W.L.	.757
Cylindrical coefficient	.681
Number of frames	94
watertight compartments	292

The hull is constructed of mild steel of domestic manufacture with frames spaced four feet apart, except when intermediate frames are required, from the stem to frame No. 75; and from this point aft the frames are spaced three feet six inches apart. The ship is divided into two hundred and ninety-two watertight compartments. The double bottom extends from frame No. 28 to frame No. 64 and runs up to the armor shelf. A cofferdam thirty-six inches wide is constructed between the berth and the protective decks, on each side of the vessel, extending from the transverse armor bulkheads to the extremities of the vessel. On the berth deck a cofferdam thirty-six inches above the deck and three feet wide is worked on each side between frames No. 25 and No. 78. The cofferdams are filled with fire-proofed corn-pith cellulose packed to a density of six pounds per cubic foot. All the wood used in the construction of the vessel is fire-proofed, and the use of wood at all is avoided wherever practicable. The upper deck and the main deck, outside the superstructure, are the only ones laid with wood, the others being covered with linoleum.

Main Deck.—On the main deck, inside the superstructure, is located the 5-inch battery in broadside, fitted in stalls formed by splinter bulkheads; on this deck are also located the bakery, galleys, executive officer's and paymaster's offices, junior officers' mess room and pantry. It also forms the principal part of the crew's messing and berthing space, and has much the appearance of the old-time gun deck.

Berth Deck.—On this deck are situated the quarters of the admiral, captain and officers and a berthing space for a part of the crew, and in addition the ice machine and refrigerating rooms, sick bay and dispensary, torpedo rooms, armory, lavatories and coal bunkers above protective deck. On the protective deck are the fresh-water tanks, store rooms, and a small berthing compartment.

Splinter and Platform Decks and Hold.—Below the protective deck are the machinery spaces, dynamo room, coal bunkers, holds, chain lockers, trimming tanks, store rooms, magazines, shell rooms, blower rooms, central station for interior communications, steering gear, engineers' and ordnance work shops, air compressors and ammunition hoists.

There are thirty-four coal bunkers with a total capacity of 1,591.48 tons at forty-three cubic feet to the ton. They are distributed as follows: Eight on the berth deck with a capacity of 272.02 tons; twelve on the splinter deck with a capacity of 289.63 tons, and fourteen in the hold with a capacity of 1,029.83 tons. They are filled from either the upper or the main deck through portable chutes and trunks fitted between decks. The trunks have shunt doors fitted at the tops where they pass through the bunkers on the berth deck, and vertical doors at the bottom, for passing the coal from the upper to the lower bunkers. Armored shutters are fitted in the trunks where they pass through the protective deck. Trolley rails and buckets are fitted fore and aft in the outboard hold bunkers, with portable sections in the wake of watertight doors, for the transportation of coal. Escape doors are fitted to all bunkers, those on the berth deck open to main deck (circular plates), those on the splinter deck to ammunition passage (swinging doors), and those in the hold to deck of ammunition passage (circular plates). Steam fire-extinguishing pipes are fitted to all bunkers and holds. Over the vertical watertight sliding doors of the hold bunkers are fitted screen doors, in the shape of a hood, designed to take the weight of the coal from the watertight doors, so that they may be easily closed at any time.

There are two ash chutes on each side fitted inside the vessel. The upper ends of the chutes extend above the main deck, where hoppers are formed inside, and so arranged that the fire-main pressure may be used to clear the chute. Trolley ways for carrying the ash bunkers are fitted under the deck beams above, leading from the ash hoists to the chutes.

For convenience in referring to the compartment plans of

the ship the following list of capacity of each coal bunker is given.

HOLD AND PLATFORM DECK.

Compartment.	Capacity.	
	Cubic feet.	Tons.
B- 5	2,031	47.23
B- 6	1,781	41.42
B- 7	4,675	108.72
B- 8	4,675	108.72
B-15	3,598	83.68
B-16	3,598	83.68
B-19	3,717	86.44
B-20	3,717	86.44
B-27	3,707	86.21
B-28	3,707	86.21
B-25	3,214	74.74
B-26	2,895	67.32
C- 3	1,484	34.51
C- 4	1,484	34.51
Total..... 14	44,283	1,029.83
SPLINTER DECK.		
B-31	1,584	36.84
B-32	1,584	36.84
B-35	1,151	26.77
B-36	1,151	26.77
B-53	1,673	38.90
B-52	1,693	39.37
B-48	596	13.86
B-49	596	13.86
B-59	601	13.98
B-60	601	13.98
C-17	612	14.23
C-18	612	14.23
Total..... 12	12,454	289.63
BERTH DECK.		
B-102	1,103	25.65
B-103	714	16.61
B-114	1,700	39.53
B-115	1,700	39.53
B-123	1,727	40.16
B-124	1,727	40.16
B-131	1,510	35.12
B-132	1,516	35.26
Total..... 8	11,697	272.02
Total ship..... 34	68,434	1,591.48

Drainage System.—The main drain pipe is of galvanized steel, 14 inches in diameter, and runs from the forward boiler rooms

along the port side of the center-line bulkhead above the inner bottom to the engine rooms, having branches connecting it with the starboard compartments. It is fitted with screw-down non-return valves in each boiler room, and with screw-down valves in each engine room, all worked from the berth deck. The suction pipes leading from the valves in the boiler rooms do not dip into drainage wells, but have their mouths located as low down as practicable and covered with coarse strainers. The main drain pipe leads to the main circulating pumps, and is also provided with branches and flanges for connections to the principal steam pumps, other than the main feed pumps.

For the auxiliary drainage system manifolds are fitted in the forward and after eight-inch handling rooms, and in convenient locations throughout the machinery space, with suction pipes leading to the double-bottom compartments, trimming tanks and principal lower compartments of the ship, and to sea connections as required. Where these pipes drain water from compartments above the inner bottom a small well is fitted projecting six inches into the inner bottom and covered by a plate strainer. All manifold valves are worked from the manifolds only. A five-inch drain connects the forward and the after manifold, with flanges for the pump connections. In the boiler and engine compartments the suctions are fitted with flanges for a direct connection to the pumps in that compartment, and the crank pits are drained independently of the remainder of the bilge. The compartments above the protective deck are drained by scuppers or portable pumps. The small store rooms below the protective deck are drained by portable pumps, and the coal bunkers below the protective deck by their own vertical sliding doors. The waste water from bath and wash rooms is led by pipes to tanks (two) located in the after part of the engineer's workshop, and is pumped overboard by an ejector.

ARMOR.

The armor consists of a side belt of Harveyized nickel-steel extending 3 feet 6 inches above and 4 feet below the 23½-foot load line. The thickness amidships of the side belt is 16½ inches at

the top, and 9½ inches at the top of the armor shelf. The maximum thickness of armor at the water line is maintained from the center line of the after barbettes, where the belt begins, to the forward coal-bunker bulkhead, tapering to 10½ inches to the center line of forward barbettes, thence to 4 inches in a distance of 30 feet, which thickness is then maintained to the bow of the vessel. The triangular armor extends from the slopes of the protective deck to the top of the armor belt at the forward and after ends of the machinery spaces, the forward bulkhead being 10 inches and the after bulkhead 12 inches in thickness. Above the side belt there is a casemate 6 inches thick made up of two ½-inch plates and one 5-inch plate; the athwartship bulkheads are 4 inches thick, and are worked from the sides of the vessel to the centers of the barbettes. The thickness of the superstructure armor is 6 inches. The protective deck between armor bulkheads is 2¾ inches thick, and at the extremities on side slopes are fitted plates of armor 4 inches thick. The splinter bulkheads between 5-inch gun stations are each one piece of plate, 80 pounds per square foot.

The barbettes are 15 inches thick at the front and 12½ inches thick at the rear; the 13-inch turrets are 17 inches thick at the front and 15 inches thick at the rear; the 8-inch turrets are 11 inches thick at the front and 9 inches thick at the rear. The conning tower is elliptical in shape, and is 10 inches thick. An armor tube 7 inches thick is fitted between the base of the conning tower and the protective deck, to afford protection to the voice pipes, electric wires, engine telegraphs, steering gear and engine tell-tales.

ARMAMENT.

The main battery consists of four 13-inch breech-loading rifles, 35 calibers, mounted in pairs, in two balanced turrets, on the fore-and-aft center line of the ship, on the main deck; four 8-inch breech-loading rifles, 40 calibers, mounted in pairs, in two turrets superposed on the 13-inch turrets; and fourteen 5-inch rapid-fire breech-loading rifles, 40 calibers, mounted in broadside, on the main deck within the superstructure.

The secondary battery consists of twenty 6-pounder rapid-fire

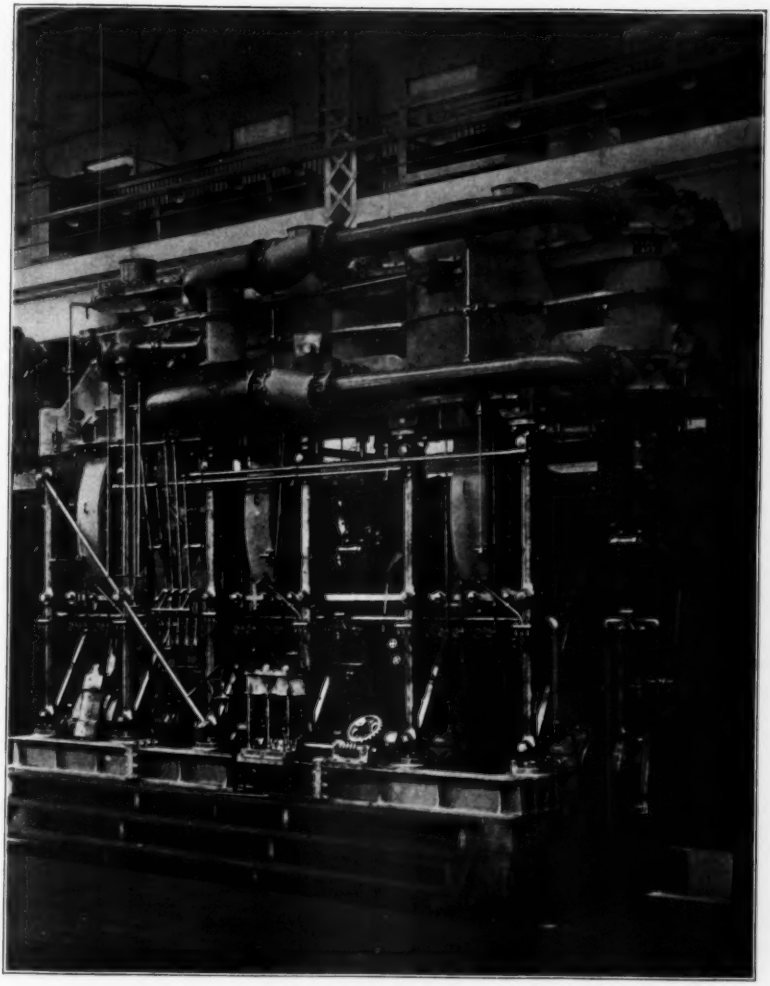
guns, eight 1-pounder rapid-fire guns, four of which are automatic, four Colt automatic machine guns, and two 3-inch field guns. There are four tubes for Whitehead torpedoes, two on each side, discharging directly from the berth deck. The turrets are trained by electricity, and the 13-inch guns are elevated and loaded by the same power. The 5-inch guns are worked by hand on central-pivot carriages.

The boats carried are as follows:

One 40-foot steam cutter.
One 33-foot steam cutter.
One 33-foot sailing launch.
Three 30-foot cutters.
Two 30-foot whaleboats.
One 30-foot gig.
One 30-foot barge.
Two 20-foot dinghies.
Two 18-foot balsas.

MAIN ENGINES.

There are two three-cylinder triple-expansion engines of the vertical, inverted, direct-acting type, placed abreast of each other in separate watertight compartments, the H.P. cylinders being forward. The engine framing consists of twelve wrought-steel, cylindrical columns, well trussed and stayed diagonally, fore-and-aft and athwartship; in addition, the H.P. and L.P. cylinders of one engine are secured to the corresponding cylinders of the other, the rod passing through a stuffing box in the center-line bulkhead; also the high and low-pressure cylinders are secured longitudinally to the athwartship bulkheads. The valves are all of the single-ported piston type, there being one for each high-pressure cylinder, two for each intermediate and four for each low-pressure cylinder. The link motion is of the double-bar Stephenson type, and the valve gears of the three cylinders are interchangeable. Independent adjustable cut-off blocks are fitted to each link, with a range from .5 to .7 of stroke. The main valves are provided with balance pistons, the cylinders of which form part of the upper covers of the valve chests. There are no



ONE MAIN ENGINE.
(SET UP IN SHOP.)

starting valves on the cylinders, provision being made for starting the engines by admitting live steam to the receivers. The high-pressure cylinder is steam jacketed around the working linings, and the intermediate and the low-pressure cylinders are steam jacketed around the working linings and at both ends. Each main engine is fitted with a double-disc, balanced, stop and throttle valve, worked by a lever and adjusted by a screw stem and hand wheel from the working platform. The main steam pipes are of copper, and where above 9½ inches in internal diameter are strengthened with steel bands spaced 6 inches between centers. In the starboard engine room there is a 50-gallon distributing oil tank for supplying the oil manifolds of both main engines. This tank is supplied from the main tanks by a Worthington duplex steam pump, and by a hand pump, and can be used as either a pressure or a gravity tank. The main pistons are steel castings, dished, and are each fitted with two packing rings and a follower. The piston rods are of forged nickel-steel, oil tempered and hollow, the outside diameter being 7½ inches and the inside diameter 3½ inches; a screw plug is fitted and riveted over at the upper end. The connecting rods, with their caps and bolts, are of forged nickel-steel, oil tempered; the rods have a 4½-inch axial hole bored through their entire length. The body of the crosshead is forged on the end of the piston rod, and a manganese-bronze slipper, whose sliding faces are fitted with white metal, is bolted to its under side. The crosshead guides are of cast iron, and are made hollow for the circulation of water to keep them cool. At the top they are bolted to lugs cast on the cylinder casings, and at the bottom are bolted to forged-steel cross bars, secured to the engine columns. The backing guides are also of cast iron, and are bolted to flanges provided for that purpose on the go-ahead guides. The eccentrics are of cast iron. Each backing eccentric is securely keyed on the shaft, and each go-ahead eccentric is secured to the corresponding backing one by through bolts in slotted holes. The eccentric straps are of composition, faced with white metal, and the eccentric rods are of forged steel. The I.P. and L.P. valve stems have cast-steel crossheads which take hold of the

link blocks directly. Each engine bedplate consists of three sections of steel castings.

There is a steam float-lever, reversing gear, with a hydraulic controlling cylinder, which can also be adjusted to work by a hand pump, there being a common piston rod for both steam and water pistons.

The turning engine is a double, inverted, simple, 7 by 5 engine, operating a worm shaft, which in turn operates a second worm shaft and gear made to readily engage in a worm wheel secured on forward end of low-pressure section of crank shaft. The turning-engine shaft is squared at the end and fitted with a ratchet wrench for turning by hand.

ENGINE DATA.

Cylinders, number for each engine	3
H.P., diameter, inches	33½
I.P., diameter, inches	51
L.P., diameter, inches	78
Stroke of pistons, inches	48
Valves, H.P. (one for each cylinder), diameter, inches	19½
I.P. (two for each cylinder), diameter, inches	18
L.P. (four for each cylinder), diameter, inches	18
Balance pistons, H.P., diameter, inches	6
I.P., diameter, inches	7½
L.P., diameter, inches	7½
Valve stems, H.P. (1), diameter, inches	2¾
H.P. (1), diameter through valve, inches	1⅞
I.P. (2), diameter, inches	2¾
I.P. (2), diameter through valve, inches	1⅞
L.P. (4), diameter, inches	2¾
L.P. (4), diameter through valve, inches	1⅞
Main steam pipe (13 inches diameter) area cross section, square inches	132.73
Exhaust pipes to I.P. cylinder, (1) 17 inches H.P. end, 17 inches I.P. end, area of cross section, square inches	226.86
L.P. cylinder, (4) 15 inches I.P. end, (8) 11 inches L.P. end, area of cross section, square inches	706.50 759.88
condenser, (2) 19 inches diameter, area of combined cross section, square inches	566.77
Volume swept by H.P. piston (mean), per stoke, cubic feet	23.84
I.P. piston (mean), per stroke, cubic feet	56.09
L.P. piston (mean), per stroke, cubic feet	132.04
Net area of I.P. to H.P. piston	2.34
L.P. to I.P. piston	2.36

Net area of L.P. to H.P. piston	5.53
Clearances of H.P. cylinders, per cent.....top, 18.9; bottom,	22.8
I.P. cylinders, per cent.....top, 18.9; bottom,	24.7
L.P. cylinders, per cent.....top, 17.5; bottom,	22.9
Piston rods, diameter, inches	7½
length from piston to crosshead, feet and inches	6– 6½
Connecting rods, length from center to center, feet	8
diameter of upper end, inches	7⅞
diameter of lower end, inches	8½
crosshead bolts (2), diameter, inches	4½
crank-pin bolts (2), diameter, inches	4½
Crossheads, surface (ahead), square inches	459
(backing), square inches	357
pins, diameter, inches	9¾
length, inches	14
Reversing gear, steam cylinder, diameter, inches	15
controlling cylinder, diameter, inches	7½
Crank shafts, diameter, inches	14¾
axial hole, inches	7½
coupling discs, diameter, inches	29
thickness, inches	3½
bolts in one flange (6), diameter, inches	3½
journals, diameter, inches	14¾
length, inches	16½
length of each section, feet and inches	8–10
Crank pins, diameter, inches	14¾
length, inches	17
axial hole, inches	7½
Crank webs, width, inches	16½
thickness, inches	10
Thrust shaft, diameter, inches	14
diameter of coupling disc, inches	29
axial hole, inches	9
collars, number each shaft	11
diameter, inches	21½
thickness, inches	2
distance between, inches	3½
surface, total for both engines, square inches	4,600.64
length, feet and inches	15– 5½
Line shafts, diameter, inches	14
axial hole, inches	9
diameter of coupling discs, inches	29
length, feet and inches	31–10½
Propeller shafts, diameter, inches	14¾
axial hole, inches	9¾
Propeller shafts, outboard, length, feet and inches	26– 5½

Propeller shafts, outboard, coupling, diameter, inches	21
length, feet and inches	4– 8½
inboard, length, feet and inches	31–10
Stern bracket bearing, length, inches	48½
diameter, inches	16 15/16
tube bearing, length, forward, inches	40¾
aft, inches	42

Shafting and Bearings.—The crank shafts are of forged steel, and for each engine are made in three interchangeable and reversible sections, the cranks being 120 degrees apart, and for the ahead motion follow in the order H.P., I.P. and L.P. There is a 7½-inch axial hole through crank shaft and pin. The line, thrust and propeller shafting is hollow and of forged nickel-steel. The propeller shafts are fitted with a composition casing from inboard of the stern-tube stuffing box to the propeller hub. The propeller shaft is in two sections connected by an outboard sleeve coupling fitted near the after end of the stern tube, and protected by a water-tight covering. The thrust bearings are of the horseshoe pattern; the pedestals are of cast iron, the ends and side walls forming an oil trough; at each end there is a bearing, lined with white metal, for taking the weight of the shaft. The horseshoes are eleven in number and are of cast steel, faced with white metal, and fitted with oil cups and holes for the distribution of oil to the bearings. At each end of the bearing there is a divided stuffing box and gland to prevent the escape of oil. The pedestal is bolted to a cast-iron sole plate, fitted with wrought-iron wedges at each end of the pedestal for adjusting the bearing fore and aft.

Main Condensers.—There are two main condensers, one for each engine, the shells are of wrought-steel plate, with an angle-iron riveted around each end forming a flange for securing the water chests. The water chests and tube sheets are of composition. The circulating water passes through the tubes. Baffle, circulating and tube-supporting plates are fitted. There are by-pass valves in the after water chests to allow the water from the circulating pumps to pass directly overboard.

Diameter of shell (inside), feet and inches	5- 8½
Thickness of shell, inch	5/16

Length over heads, feet and inches	13- 4
Tubes, diameter (outside), inch	$\frac{5}{8}$
length between tube sheets, feet and inches	11- 6
thickness, No. 18 B.W.G., inch	.049
number in each condenser	3,749
Cooling surface, each condenser, square feet	7,050
Total cooling surface, square feet	14,100
Ratio of total cooling to total heating surface	1 to 1.56

Main Air Pumps.—For each main engine there is a Worthington twin-cylinder, vertical, single-acting air pump. The steam cylinders are placed directly over the pump cylinders, the pump rods and piston rods forming a continuous length. The pumps are connected by means of a beam, which is pivoted at its center, and from which beam the valve motion is actuated. The beam receives its motion through links swinging from crossheads on the pump and piston rods. The pump valves are each made of three flat discs of rolled manganese-bronze.

Diameter of steam cylinders (2), inches	12
pump cylinders (2), inches	25
Stroke, inches	18
Diameter of piston rods, inches	$2\frac{7}{16}$
pump rods, inches	$2\frac{3}{4}$
Diameter of pump valves, inches	3, 4, $4\frac{1}{2}$
Ratio of volume swept by L.P. piston, net area, per stroke, to that of the two air-pump buckets, per stroke	13

Main Circulating Pumps.—For each condenser there is a centrifugal, double-inlet circulating pump, which is arranged to draw from the sea, bilge and main drain pipe, and to discharge either into the condenser or directly overboard. The sea and bilge injection valves are fitted with a self-locking arrangement so that both cannot be operated at the same time. One of these pumps was tested under conditions assimilated to that of drawing water from the bilge and discharging directly overboard, the length and size of the piping and the head at discharge being the same as would occur in actual service. The velocity at discharge was measured by a small propeller, and the results were well over their rated capacity of 10,000 gallons per minute.

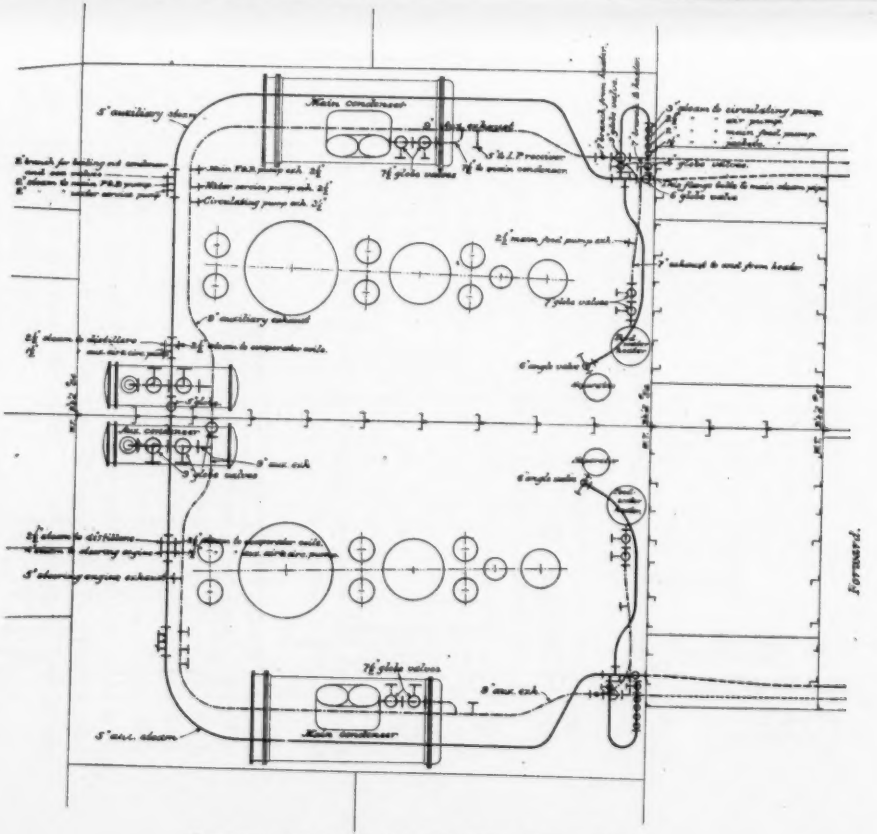
Diameter of steam cylinders, inches	11
Stroke, inches	8
Diameter of pump runner, inches	42
Width of runner, inches	8¼
Diameter of inlet and of outlet nozzle, inches	15½

Auxiliary Condensers.—There is in each engine room an auxiliary condenser connected with the auxiliary exhaust pipes. The heads and shell are of composition and the tube sheets of rolled brass. Each has a Worthington horizontal, duplex, combined air and circulating pump, the steam cylinders being between the water cylinders, and all the pistons being on one rod. The tubes are arranged and packed as in the main condensers.

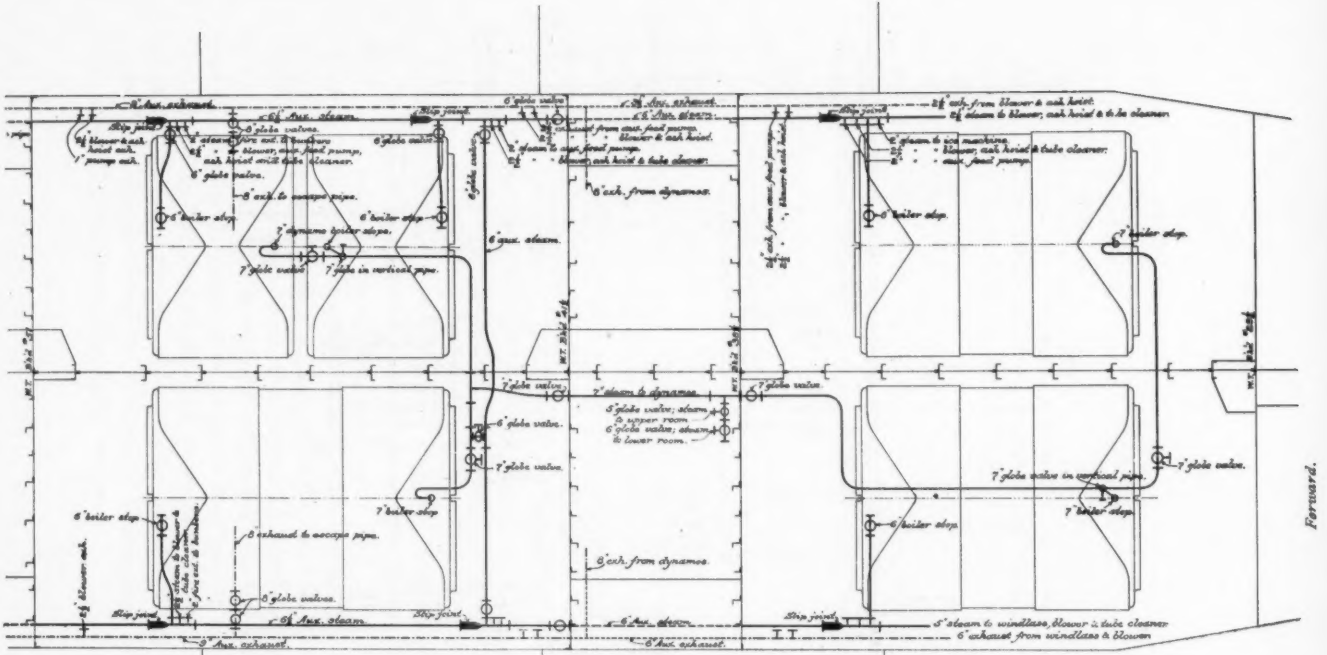
Cooling surface, one condenser, square feet	801
Diameter of steam cylinders, inches	7½
circulating-pump cylinders, inches	8½
air-pump cylinders, inches	8½
Stroke, common, inches	10

Feed-Water Heaters.—In each engine room there is a feed-water heater which is similar in construction to a condenser. The auxiliary exhaust pipe has a by-pass valve, so that the exhaust steam may be passed around the tubes of the heater and thence to the condenser. The heaters are located between the feed pumps and the feed main, and the valves are so arranged that the feed water can pass directly to the feed main without passing through the heaters. The heating surface is 496.5 square feet for each heater. The tubes are 1 inch in outside diameter, No. 13 B.W.G. in thickness, and are expanded into the tube sheet. The tubes are tinned inside and out.

Screw Propellers.—The propellers are rights and lefts, of manganese-bronze, each with three adjustable blades bent back 30 inches. They are true screws, with the pitch adjustable from 16 to 18 feet. Each boss is secured to the shaft by two feather keys and a wrought-steel nut screwed on and locked in place. The end of the hub is covered with a composition cap. The blades and boss are tinned, and the outboard sections of propeller shafts are protected by a covering of insulated copper wire, wound tightly around the shaft casings.



AUXILIARY STEAM AND EXHAUST PIPES, ENGINE ROOMS.



AUXILIARY STEAM AND EXHAUST PIPES, FIRE ROOMS.

Number of blades	3
Diameter, feet and inches	16– 9
of hub, feet and inches	4– 4½
Length of hub, feet and inches	3– 1
Pitch as set, feet and inches	17– 3
Greatest width of blade, feet	5
Helicoidal area of each screw, square feet	84.2
Projected area, square feet	69.2
Disc area, square feet	220.35
Pitch ÷ diameter	1.03

BOILERS.

There are three double-ended and two single-ended steel boilers of the horizontal, return, fire-tube type, all 15 feet 8 inches in diameter. Each double-ended boiler has eight and each single-ended boiler four corrugated furnaces. The shell of each double-ended boiler is made up of three courses of three plates each; the longitudinal joints are treble riveted with double butt straps; the circumferential joints are lapped and treble riveted, and the heads lapped and double riveted. The shell of each single-ended boiler is in one course of four plates, double butt strapped and treble riveted, the joints with the head lapped and double riveted. The joints in the furnaces and combustion chambers are single riveted. The heads of all boilers are curved at the top to a radius of 3 feet 7 inches.

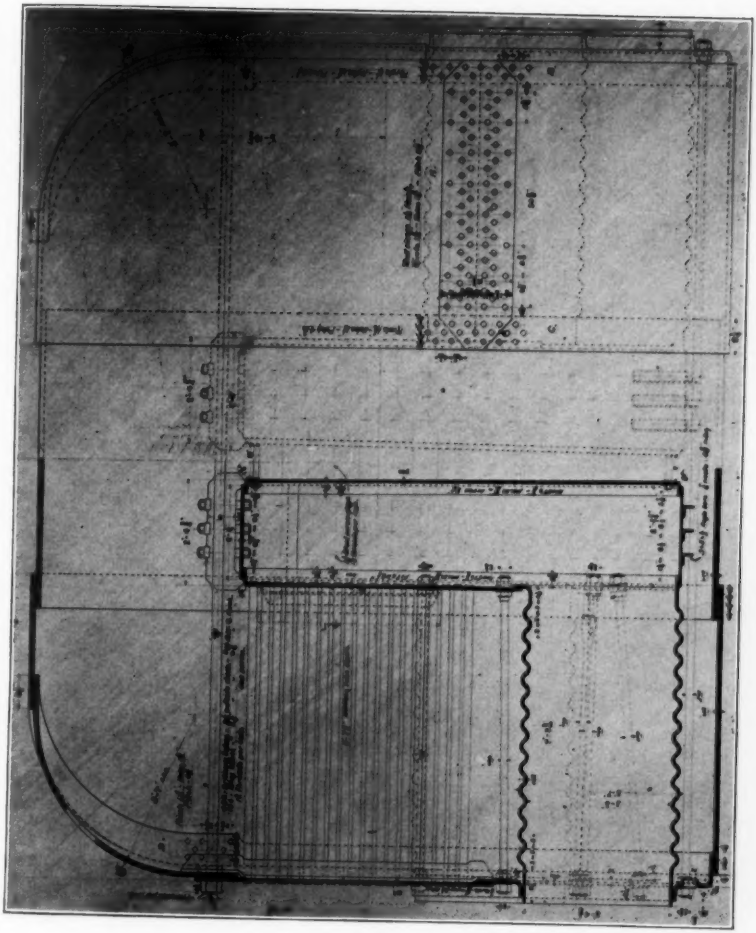
The furnaces are fitted with the ordinary cast-iron fixed grate bars. Each double-ended boiler has four 4½-inch spring safety valves, two in one case, and each single-ended boiler two 4½-inch safety valves in one case. The internal feed pipes are fitted with suction branches to the bottom of the boilers, the combined feed and "circulated" water being discharged near the water level through down-pointing branches. The auxiliary feed pumps may also be used to circulate the water. The tubes in all boilers are of knobbled charcoal iron.

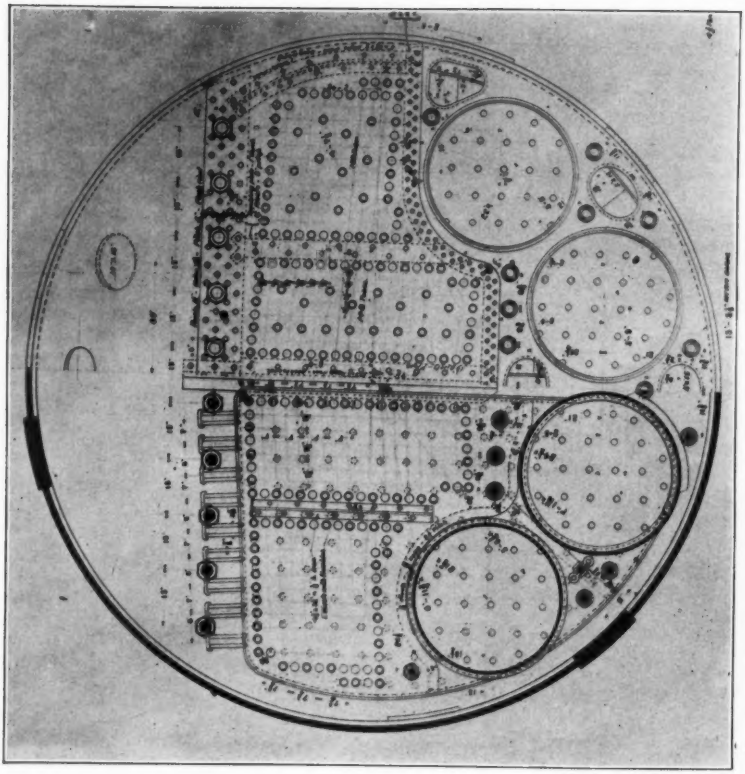
The boilers are placed fore and aft in four water-tight compartments, the two single-ended boilers occupying the after port compartment. The passageways are outboard and alongside of the boilers, with passage amidships connecting the port engine room with the port after fire room. There are two athwartship fire

rooms in each boiler compartment, and eight fire rooms in all. There are two circular smoke pipes. The working pressure is 180 pounds per square inch.

DOUBLE-ENDED BOILERS.

Length, feet	one of 21 and two of 19
Diameter, outside of all, feet and inches	15- 8
Thickness of shell and heads at top, inches	$1\frac{7}{16}$
heads, bottom, inch	$\frac{3}{4}$
tube sheets, inch	front $\frac{7}{8}$, back $\frac{3}{4}$
furnaces, inch	$\frac{9}{16}$
Combustion chambers, number in each boiler	4
thickness of plates, inch	$\frac{9}{16}$
depth at top, inches	$27\frac{1}{2}$
Furnaces, greatest internal diameter, feet and inches	3- $5\frac{7}{8}$
least internal diameter, feet and inches	3- 3
length of grate, feet and inches	6- 7
number in each boiler (corrugated)	8
Tubes, outside diameter, inches	$2\frac{1}{4}$
length between tube sheets, 21-foot boiler, feet and inches	7- $7\frac{3}{8}$
19-foot boilers, feet and inches	6- $7\frac{3}{8}$
number of ordinary	816
number of stay	332
spaced vertically, inches	$3\frac{1}{4}$
horizontally, inches	$3\frac{1}{2}$
thickness of ordinary, B.W.G. No. 10, inch	.132
stay, B.W.G. No. 6, inch	.203
Diameter of rivets in shell sheets, inches	$1\frac{5}{16}$
screw stays, inches	$1\frac{1}{2}$
Number and diameter of through upper braces, inches	10 of $2\frac{3}{4}$
lower braces, inches	2 of $1\frac{3}{4}$
braces from head to back tube sheets, inches	15 of $1\frac{3}{4}$
Heating surface, tube, square feet, 19-foot boiler, 4,473; 21-foot boiler,	5,150
plate, square feet, 19-foot boiler, 847; 21-foot boiler,	901
total, square feet, 19-foot boiler, 5,320; 21-foot boiler,	6,051
Grate surface, square feet	171.2
Area through tubes, square feet	23.8
over bridge walls, square feet	24.5
Volume of furnaces and combustion chambers above grates, 21-foot boiler, cubic feet	725
Volume of furnaces and combustion chambers above grates, 19-foot boiler, cubic feet	699
Steam room, 4 inches above highest heating surface, 21-ft. boiler, cu. ft.	808.5
19-ft. boiler, cu. ft.,	716





Water surface, 4 ins. above highest heating surface, 21-ft. boiler, sq. ft..	284.75
19-ft. boiler, sq. ft..	258
Smoke pipes (2), diameter, feet and inches.....	8–0
area of both, square feet.....	100.6
height above lowest grates, feet.....	87
Number and diameter of safety valves (2 on one base), inches.....	4 of $4\frac{1}{2}$
Diameter of boiler main stop valves, inches.....	$9\frac{1}{2}$
auxiliary stop valves, inches.....	7
Totals for three boilers:	
Heating surface, tube, square feet.....	14,096
plate, square feet.....	2,595
total, square feet.....	16,691
Grate surface, square feet.....	513.6
Area through tubes, square feet.....	71.4
over bridge walls, square feet.....	73.5
Volume of furnaces and combustion chambers above grates, cu. ft.	2,123
steam room, cubic feet.....	2,240.5
Area of water surface, square feet.....	800.75
Ratios:	
Tube H.S. to G.S.....	27.44
Plate H.S. to G.S.....	5.05
Total H.S. to G.S.....	32.40
Area through tubes to G.S.....	.139
Volume of furnaces and combustion chambers above grates to G.S..	4.13
Steam room per square foot of G. S.....	4.36

SINGLE-ENDED BOILERS.

Length, feet and inches.....	9–$11\frac{1}{2}$
Diameter, outside, feet and inches.....	15– 8
Thickness of shell, inches.....	$1\frac{7}{16}$
heads, top, inches.....	$1\frac{7}{16}$
bottom, inch.....	$\frac{3}{4}$
tube sheets, inch.....	front $\frac{7}{8}$, back $\frac{3}{4}$
furnaces, inch.....	$\frac{9}{16}$
Combustion chambers, number in each boiler.....	2
thickness of plates, inch.....	$\frac{9}{16}$
depth at top, inches.....	$27\frac{1}{2}$
Furnaces, greatest internal diameter, feet and inches.....	3– $5\frac{1}{8}$
least internal diameter, feet and inches.....	3– 3
length of grate, feet and inches.....	6– 7
number in each boiler, corrugated.....	4
Tubes, outside diameter, inches.....	$2\frac{1}{4}$
length between tube sheets, feet and inches.....	6– $6\frac{1}{8}$
Tubes, number of ordinary.....	428
stay.....	164
spaced vertically, inches.....	$3\frac{1}{2}$

Tubes, spaced horizontally, inches	3½
thickness of ordinary, B.W.G. No. 10, inch	.132
stay, B.W.G. No. 6, inch	.203
Diameter of rivets in shell sheets, inches	1 5/16
screw stays, inches	1½
Pitch of screw stays, inches	7 and 7½
Number and diameter of through upper braces, inches	10 of 2¾
lower braces, inches	3 of 1¾
braces from head to back tube sheets, inches,	14 of 1¾
Heating surface, tube, square feet	2,280
plate, square feet	426.4
total, square feet	2,706.4
Grate surface, square feet	85.6
Area through tubes, square feet	12.42
over bridge walls, square feet	12.25
Volume of furnaces and combustion chambers above grates, cubic feet,	349
Steam room, water four inches above highest heating surface, cu. ft..	355
Water surface, water four inches above highest heating surface, sq. ft..	116
Number and diameter of safety valves (2 on one base), inches	2 of 4½
Diameter of boiler stop valves, inches	7
auxiliary stop valve, inches	6
Totals for two boilers:	
Heating surface, tube, square feet	4,560
plate, square feet	852.8
total, square feet	5,412.8
Grate surface, square feet	171.2
Area through tubes, square feet	24.84
over bridge walls, square feet	24.50
Volume of furnaces and combustion chambers above grates, cubic feet,	698
steam room, cubic feet	710
Area of water surface, square feet	232
Ratios:	
Tube H.S. to G.S.	26.63
Plate H.S. to G.S.	4.92
Total H.S. to G.S.	31.62
Area through tubes to G.S.	.145
Volume of furnaces and combustion chambers above grates to G.S...	4.07
Steam room per square foot of G.S.	4.14

ALL BOILERS.

Heating surface, tube, square feet	18,656
plate, square feet	3,447.8
total, square feet	22,103.8
Grate surface, square feet	684.8
Area through tubes, square feet	96.24
over bridge walls, square feet	98.00

Volume of furnaces and combustion chambers above grates, cubic feet,	2,821
steam room, cubic feet	2,950.5
Area of water surface, square feet	1,032.75
Ratios:	
Tube H.S. to G.S.	27.24
Plate H.S. to G.S.	5.03
Total H.S. to G.S.	32.28
Area through tubes to G.S.	.14
Volume of furnaces and combustion chambers above grates to G.S.	4.11
Steam room per square foot of G.S.	4.31

Forced Draft.—The closed fire-room system of forced draft is used. The air is supplied by eight Sturtevant blowers, one in each fire room. The fans are driven by two-cylinder, vertical, simple, enclosed engines with cranks at 180 degrees.

Diameter of steam cylinders, inches	5
Stroke, inches	4
Diameter of fan, inches	60
Width of fan at rim, inches	14
Area of induction nozzle, square inches	1,060.7
Area of eduction nozzle, square inches	2,220

Feed Pumps.—There are two main and four auxiliary feed pumps, all of the Admiralty type, Worthington duplex, and all of the same size, 10 inches by 7 inches by 12 inches, with a capacity of 400 gallons per minute. The main feed pumps are located one in each engine room and draw water from the feed tanks and air-pump suctions and deliver to the boilers; the auxiliary feed pumps draw from the feed tanks, the air-pump suctions, the sea, the drainage system and the boilers, and discharge into the boilers, fire main or overboard. These pumps are located one in each of fire rooms Nos. 3, 4, 5 and 6. The discharges of the main and auxiliary pumps are not connected, the auxiliary feed pumps only feed through the auxiliary feed main. In the port after fire room there is a small duplex Worthington pump, 4½ inches by 3 inches by 4 inches, of 65 gallons per minute capacity, for feeding the auxiliary boilers in port.

Fire and Bilge Pumps.—In each engine room there is a vertical, duplex Worthington pump which draws from the sea, the

bilge and the drainage system, and delivers into the fire main or outboard. The steam cylinders are 10 and the water cylinders 7 inches in diameter; stroke, 12 inches.

Water-Service Pumps.—In each engine room there is a vertical, duplex Worthington pump which draws from the sea, and delivers into the water-service pipes, the distiller circulating pipes, and into the fire main. These pumps have a capacity of 400 gallons per minute; size, 10 inches by 7 inches by 12 inches.

Bilge and Sanitary Pumps.—There are two single-acting plunger pumps on each main-engine shaft, driven by eccentrics; one pump on each shaft is arranged to draw from the bilge and discharge overboard; the other to draw from the sea, and discharge into the flushing main.

Grease Extractors.—A grease extractor is fitted on the discharge of both main feed pumps. It is similar in action to a Macomb strainer; the cartridge is perforated and covered with burlap, through which the water filters. By-pass valves are fitted so that the extractors may be overhauled without interrupting the boiler feed.

Feed Tanks.—There is a feed tank of 2,000 gallons capacity in each engine room. A part of the tank is fitted as a filter, into which the water from the air pumps is delivered. The filter has a movable cover and is provided with sponges. Each tank has a manhole, glass water gage, shut-off and drain cocks. An overflow pipe is fitted and so arranged that any water passing down it may be seen. Each feed-pump suction is provided with a balance valve operated by a float in the feed tank, and so arranged that no air will enter the feed pipes.

Ash Hoists.—In each fire-room hatch there is a Williamson Bros. double, reversible ash hoist, by means of which one bucket of ashes of 300 pounds (with a steam pressure of 80 pounds) can be hoisted in five seconds. The steam cylinders are $4\frac{1}{2}$ inches in diameter, with a stroke of $4\frac{1}{2}$ inches.

Steam Traps.—The separators, the jackets, the main and auxiliary steam pipes, the radiators, and all places where condensed steam can accumulate are fitted with drain pipes and locks, or valves, and with automatic traps which discharge into the feed

tanks. The traps are provided with by-pass pipes and valves for convenience in overhauling.

Engineer's Workshop.—The workshop is situated on the splinter deck, just forward of the engine rooms. It is fitted with a vertical engine, 7 inches by 7 inches, a 24-inch lathe, a 14-inch screw-cutting lathe, a shaping machine, a double-geared drilling machine, a hand drill press, combined punch and shears, and emery wheels.

Distilling Apparatus.—There are two Williamson Bros. straight-tube distillers, and two evaporators, Bureau pattern, with a combined capacity of 7,500 gallons of potable water at a temperature of 90 degrees Fahrenheit per day of 24 hours. The water-service pumps are used for the distiller-circulating water. There are two distiller feed pumps of the Worthington horizontal, duplex type, two combined brine and fresh-water pumps of the same type, and two trap pumps of the same type, except that they are vertical. There are two filters and two water meters fitted.

Ice Machine.—There is an Allen dense-air ice machine capable of producing the cooling effect of one ton of ice per day; steam cylinder, 9 inches; air-compressor cylinder, $5\frac{3}{4}$ inches, and air-expander cylinder, $4\frac{3}{4}$ inches in diameter; stroke, 10 inches. The circulating, water and primer pumps are single acting, each $1\frac{5}{8}$ inches in diameter and 10 inches stroke. The cooling pipes connect to the ice tank, to the refrigerating room and to the scuttle butt.

Ventilating Fans.—There is in each engine-room hatch a 50-inch steel-plate fan, driven by a 12-H.P. electric motor, for engine-room ventilation only. For the general ventilation of the ship there are eight 50-inch steel-plate fans, located two on the berth deck and six on the splinter deck, for supplying air to the various parts of the ship. These fans are each driven by 12-H.P. electric motors. There are also three small exhausters driven by 3-H.P. electric motors, located two on berth deck and one in the steering-engine space, for exhausting air from the crews' W. C., officers' W. C., and the steering-engine room. All the fans were furnished by the Sturtevant Company, and the electric driving motors by the General Electric Company.

Steam Cutters.—There are two steam cutters, one 40 and the other 33 feet long. They have Ward boilers, type 5-G-1, round, and 5-D, square, respectively, compound engines and keel condensers. The cylinders for the 40-foot cutter are 5 and 10½ inches in diameter by 8 inches stroke, and those for the 33-foot cutter, 4 and 8 inches in diameter by 6 inches stroke.

Telegraphs and Revolution Indicators.—There is a Cory mechanical telegraph in each engine room connected to transmitters in conning tower and pilot house, and a mechanical gong in each engine room with bell pulls in the pilot house and on the flying bridge near the after bridge. Mechanical tell-tales are fitted in the conning tower and in the pilot house to show the direction of revolution of the main engines. In each engine room there is a mechanical indicator to show the relative speed and direction of revolution of the propellers on one dial.

Telephones and Voice Pipes.—For communication between the various parts of the ship there is a complete system of telephones and voice pipes with call bell. All battle stations are connected direct to the conning tower and central station. The central station is provided for use in battle and in case of accident to conning tower.

Steering Engine.—On the after platform deck there is a Williamson Bros. combined hand and steam-steering engine: cylinder, 14 inches diameter; stroke, 11 inches. The engine is connected to a horizontal fore-and-aft shaft, on the after end of which there is a right and left-hand screw. The screw works in the crossheads, one on the starboard and one on the port side, the rudder yoke being connected by rods to these crossheads. With the steam gear the rudder can be put from hard over to hard over in 20 seconds when the ship is going full speed. The engine is controlled from the conning tower and the pilot house by means of a hydraulic telemotor or by wire ropes.

Steam Windlass.—In the windlass house forward of the forward turret there is a steam windlass. The engine is reversible, double-cylinder, vertical, direct-acting, with cylinders 15 inches in diameter, and a stroke of 14 inches. The windlass is fitted with two wild cats to take the chains.

Steam Winch.—There is a double-cylinder steam winch in the windlass house forward of forward turret. The cylinders are 8 inches in diameter; stroke, 8 inches. The winch is fitted with two drums for taking hawsers.

Electric Plant.—The installation consists in general of seven generating sets, 750 incandescent lights, 4 search lights, 2 sets of signalling apparatus, 1 main switch board, 3 main distribution boards, 7 auxiliary distribution boards, together with the necessary wire, wiring accessories, molding and fixtures and the motors given in table. The seven generating sets were made by the General Electric Company. In each set there is a 50-kilowatt dynamo of multipolar type, having a capacity of 625 ampères at 80 volts, compound-wound six-pole. The engines driving the dynamos are compound, tandem, vertical, inverted; diameter of cylinders, 10½ and 18 inches; stroke, 8 inches. The engines are designed to run with full load at 310 revolutions per minute with 110 pounds steam pressure. The bed plate is common to both engine and dynamo. The incandescent lights are of 16 and 32 candle power, designed for 80 volts.

Each of the dynamos are connected to the main switch board, and to the equalizer board. The main switch board, containing only the panels for the dynamos and lighting and motor bus bars, distributes the current to the main distribution boards, which contain the switches of lighting circuits and motor feeders. The auxiliary distribution boards receive current from main distribution boards, and are for motors only.

The ship is wired on the three-wire system, with 80 volts between neutral wire and each leg, and 160 volts between outside legs. This gives a smaller amount of copper than would be necessary in the two-wire system and a wider range in speed of the motors, which are generally wound for both 80 and 160 volts.

There are four search lights, made by the General Electric Company, two mounted on a platform on the mainmast and two on a platform on the foremast. The projectors are 30 inches in diameter, and hand controlled. All lamps are of the horizontal type with combination hand or automatic feed, and designed for

a current of 75 to 90 ampères at about 50 volts. The carbon holders are adjustable and the life of the carbon is six hours.

The signal apparatus is in two sets, one for each mast, of the usual Ardois type, and consists of four double signal lanterns to each set, cable connections and key board on the forward and after bridges.

Electric speed indicators and transmitters are fitted in the pilot house and in conning tower; also, electric helm indicators and electric steering-engine telegraphs.

There are thermostats in each coal bunker and in certain store rooms, with an annunciator on bulkhead forward of cabin.

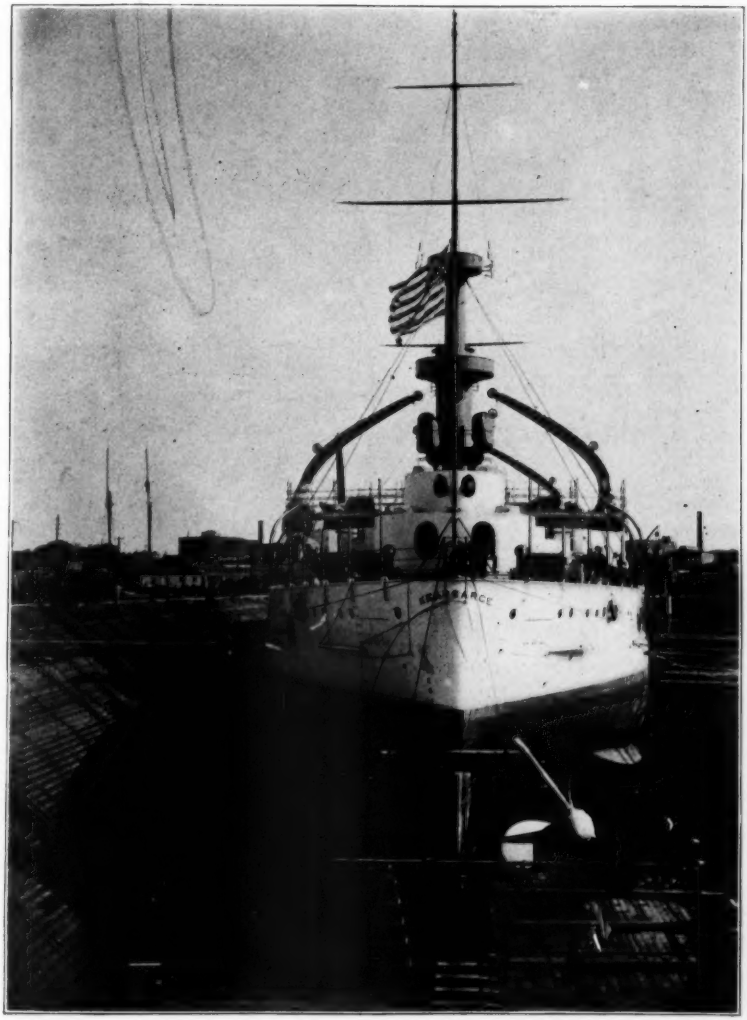
ELECTRIC MOTORS.

Name.	Number.	Horsepower.	Revolutions.	Volts.	Ampères.
Upper-deck winches	4	25	320	80 or 160	150
Main-deck winches	2	25	320	80 or 160	150
Forward boat cranes	2	50	400	80 or 160	265
After boat cranes	2	20	350	80 or 160	111
Ventilating fans	10	12	500	80 or 160	64
Small exhausters	3	3	1,030	80	35
Turret turning	4	50	400	80	600
13-inch ammunition hoist	4	20	350	80 or 160	111
8-inch ammunition hoist	4	6	375	80 or 160	37
5-inch and 6-pdr. chain ammunition hoist	10	3.75	375	80 or 160	22
6-pounder winch ammunition hoist	2	6	375	80 or 160	37
13-inch elevating	4	2.5	300	80	30
13-inch rammer	4	5	775	80	60

Pneumatic Plant for Torpedoes.—There are two 9½-inch by 4-inch duplex torpedo compressors with the three-stage air cylinders and two accumulators. Both compressors and accumulators are on the splinter deck, one of each forward and aft. The compressors were made by the Rand Drill Company.

OFFICIAL SPEED TRIAL.

The official speed trial took place off the New England coast on Monday, September 25, 1899. It consisted of two runs over a measured course of 33 nautical miles. The time occupied in



making the first run (to the northward,) was 1 hour 54 minutes and 19 seconds, and the return run, 2 hours and 55.5 seconds. Total time in making the two runs, 3 hours 55 minutes 14.5 seconds. Tidal corrections applied to the trial run made the true mean speed 16.816 knots. The weather was fair, brisk to fresh breeze from southeast, and considerable sea while going north; strong southeast wind with lumpy sea and hazy weather on return run. At the end of run, with both engines full speed ahead, the helm was put hard to port and the turn made in two and one-half times her length and came inside her own circle. All boilers were in use under forced draft, all fire rooms being connected. All the steam generated was used by the main engines and auxiliaries except that used in the steering engine, ice machine, and in the engine for the dynamo to light the engine and boiler compartments. The coal used was hand-picked Nuttalberg coal from the New River region. The boilers and engines worked well throughout the run barring one accident (the bursting of several tubes in the port feed-water heater), which happened during the run north and which indisputedly prevented the ship from making an average of at least 17.25 knots. No water was used at any time during the run on the main engines. All the auxiliaries worked well.

The engineer force during the trial consisted of the following:

7 engineers.
6 water tenders.
10 machinists.
24 oilers.
6 apprentices.
3 dynamo oilers.
3 pumpers.
3 storekeepers.
3 ice-machine men.
29 firemen.
29 coal heavers.
5 boiler makers.

128

After the trial the boilers, main engines and auxiliaries were examined and reported in good condition, except the feed-water heater above mentioned.

OFFICIAL TRIAL TRIP OVER COURSE FROM CAPE ANN TO CAPE PORPOISE. DISTANCE, 33 NAUTICAL MILES AND RETURN. SEPTEMBER 25, 1899.

No. station.	Chronometer time.			Elapsed time.	Speed, knots.	Formula used: D = Distance between stations. E = Elapsed time in minutes. S = Speed.
	h.	*m.*	*s.*			
1	3	23	10.5	.....	...	$S=\frac{D\times 60}{E}=\frac{6.6\times 60}{22.625}=\frac{396}{22.625}=17.50$
				22 *m.* 37.5 *s.*		
2	3	45	46	22.625	17.50	
				22 *m.* 37.5 *s.*		
3	4	08	25.5	22.625	17.50	
				23 *m.* 10 *s.*		
4	4	31	35.5	23.166	17.09	
				23 *m.* 4.5 *s.*		
5	4	54	40	23.075	17.16	
				22 *m.* 49.5 *s.*		
6	5	17	29.5	22.825	17.35	
				1 *h.* 54 *m.* 19 *s.*	17.32*	
				RETURN.		
6	5	41	9.5			
				24 *m.* 3 *s.*		
5	6	05	12.5	24.05	16.47	
				23 *m.* 49 *s.*		
4	6	29	1.5	23.816	16.63	
				24 *m.* 11 *s.*		
3	6	53	12.5	24.166	16.385	
				24 *m.* 37.5 *s.*		
2	7	17	50	24.625	16.08	
				24 *m.* 15 *s.*		
1	7	42	05	24.25	16.33	
				2 *h.* 0 *m.* 55.5 *s.*	16.379*	

* Average speed.

17.32
16.38

2) 33.70

16.85 Average speed for both ways.

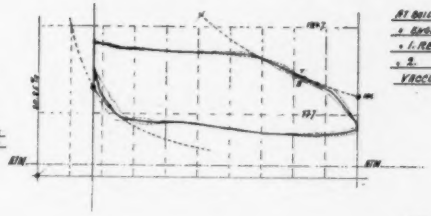
U.S.B.S. No. 5. Kearsarge.

Card No. 6. Starbd. Engine. Sept. 25. 1909. - OFFICIAL TRIAL.

Corrected for actual Cylinder Dimensions.

NO LIVE STEAM ADMITTED TO I.P. Cylinder.

H.P. Cyl. SCALE - 80.



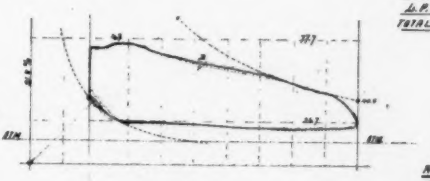
STEAM PRESSURES

	— Gauge.	— absolute
AT BOILER.	—	—
" ENGINE	170 "	184.7 "
" L. RECEIV.	63 "	77.7 "
" 2. "	12 "	26.7 "
VACCUUM.	24.8	3.18 lbs. abs.

I.H.P.

EACH Cylinder.	Reduced to L.P.	
H.P.	76.976	13.912	38.34%
I.P.	34.908	14.938	35.00 "
L.P.	13.632	13.635	32.16 "
TOTAL		42.345	100.00 "

I.P Cyl. SCALE - 40.



Revolutions 110.
Piston speed 930.

I. H.P.

H.P.	1764.0
I.P.	1880.0
L.P.	1727.5
TOTAL 1 eng.	5371.5 I.H.P.

L.P Cyl. SCALE - 20.

U.S. B.S. vs. S. - Kearsarge.

Card No. 6. Starboard Engine. Sept. 25. 1894. Official Trial.

Corrected for actual Cylinder Dimensions.

NO LIVE STEAM INTO I.P.Cyl.

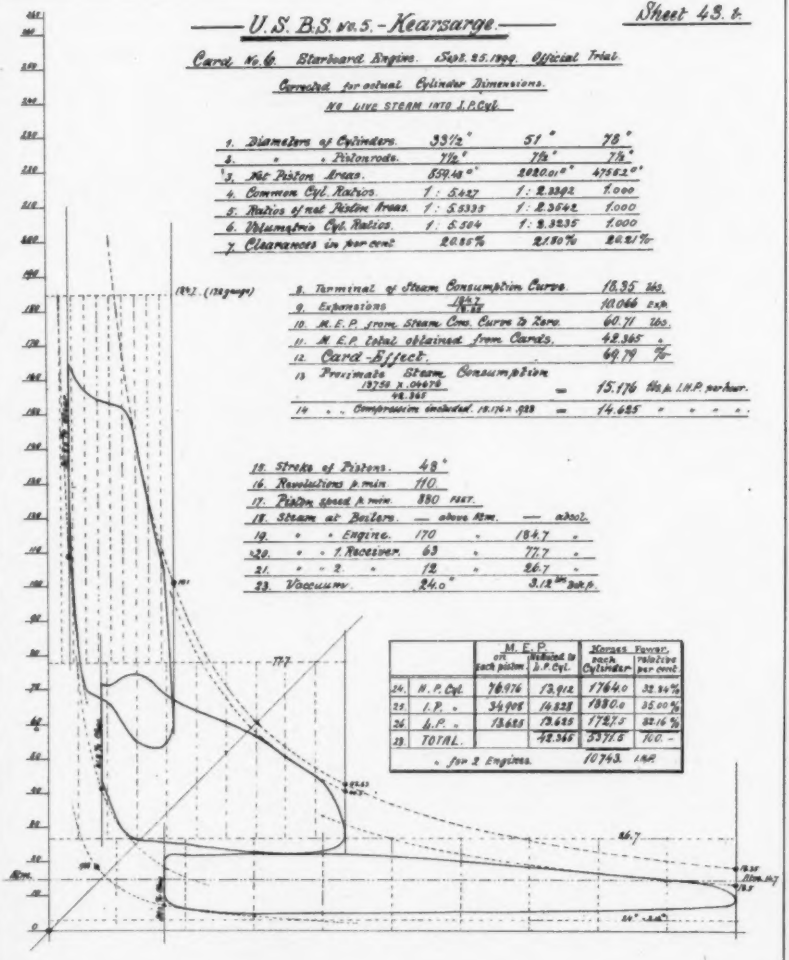
1.	Diameters of Cylinders.	33½"	51"	78"
2.	" " Piston rods.	7⅛"	7⅛"	7⅛"
3.	Net Piston Areas.	859.48"	2020.01"	4756.2"
4.	Common Cyl. Ratios.	1 : 5.627	1 : 2.3392	1.000
5.	Ratios of net Piston Areas.	1 : 5.5335	1 : 2.3642	1.000
6.	Volumetric Cyl. Ratios.	1 : 5.504	1 : 2.3235	1.000
7.	Clearances in per cent.	20.86%	21.80%	20.21%

(19.) (182 mgs)

8.	Terminal of Steam Consumption Curve.	18.35	lbs.
9.	Expansions. 18½ / 18.35	1.0066	exp.
10.	M.E.P. from Steam Cons. Curve to Zero.	60.71	lbs.
11.	M.E.P. total obtained from Cards.	42.365	"
12.	Card-Effect.	69.79	%
13.	Proximate Steam Consum.p.i.h.p. 18.35 × .04679 / 42.365	= 15.176	lbs.p. I.H.P. per hour.
14.	" " Compression included. 15.176 × .923	= 14.625	" " " "

15.	Stroke of Pistons.	48"	
16.	Revolutions p.min.	110	
17.	Piston speed p.min.	880 feet.	
18.	Steam at Boilers.	— above Atm.	— about.
19.	" " Engine.	170 "	184.7 "
20.	" " I. Receiver.	63 "	77.7 "
21.	" " 2. "	12 "	26.7 "
22.	Vacuum.	24.0"	3.12 lbs. Bar.p.

		M.E.P. on each piston.	Reduced to I.P.Cyl.	Horses Power. each Cylinder.	Horses Power. relative per cent.
24.	H.P.Cyl.	76.976	13.912	1764.0	32.34%
25.	I.P. "	34.908	14.823	1880.0	35.00%
26.	L.P. "	13.685	13.685	1727.5	32.16%
23.	TOTAL.		42.365	5371.5	100.-
	" for 2 Engines.			10743.	I.H.P.



Kearsarge. No. 6.

CONTRACT TRIAL DATA.

Draught of water, beginning of trial, forward, feet and inches	23– 4
aft, feet and inches	23–10
end of trial, forward, feet and inches	23– 2
aft, feet and inches	23– 8
mean, forward, feet and inches	23– 3
aft, feet and inches	23– 9
average on trial, feet and inches	23– 6
Displacement (mean), tons	11,550
Area immersed midship section, square feet	1,618
Wetted surface, square feet	33,700
Mean speed, knots per hour	16.816
I.H.P., main engines only	11,674.3
main engines, air, circulating and feed pumps. (B)	11,787.856
all machinery in use	11,954.37
$Speed^3 \times$ area immersed midship section $\div$ I.H.P. (B)	652.67
$Speed^3 \times displacement^{\frac{2}{3}} \div$ I.H.P. (B)	206.11
I.H.P. per 100 square feet wetted surface, (B)	34.98
Screw propellers, number	2
number of blades each	3
diameter, feet and inches	16– 9
helicoidal area, square feet	84.2
pitch on trial, feet and inches	17– 3

SYNOPSIS OF STEAM LOG.

	Starboard.	*Port.*
Slip of screws, per cent	12.93	13.3
Revolutions of main engines per minute	113.6	114.5
mean	114	
Piston speed, feet per minute	908.8	916
Steam pressure (mean) at engines	172.4	169
first receiver, absolute	79.6	82.4
second receiver, absolute	28	29.7
Vacuum in condenser, inches	24.6	24.5
Throttle-valve opening	Wide.	
Steam cut-off in fraction of stroke from beginning, H.P	.67	.66
I.P	.72	.71
L.P	.70	.69
Temperatures in degrees Fahrenheit, Engine rooms	88.1	
Injection	61	61
Discharge	125.3	125.3
Feed at tank	124.7	139.8
Air pressure in fire rooms in inches of water	1.089	
Mean effective pressures, H.P	79.75	79.78
I.P	36.94	35.75
L.P	14.63	14.635
Aggregate equivalent pressure referred to L.P. piston	44.74	44.23

		Starboard.	*Port.*
Revolutions or double strokes per minute,	Main air pumps	17.1	27.4
	Main circulating pumps	134.6	178
	Main feed pumps, average	34	
	Eight forced-draft blowers, av'ge	427	
I.H.P.	H.P. cylinder	1,887.07	1,894.63
	I.P. cylinder	2,055.80	1,996.45
	L.P. cylinder	1,916.92	1,923.43
	Collective, each main engine	5,859.79	5,814.51
	Main air pumps, each	9.116	10.54
	Main circulating pumps	11.52	22.38
	Four main boiler feed pumps	60	
	Eight forced-draft blowers	76.512	
	Other auxiliaries	90	
	Collective, main engines, air, feed and circulating pumps (B)	11,787.85	
	Total all machinery in use	11,954.37	
Square feet cooling surface (2) main condensers		14,100	
per I.H.P. main engines		1.18	
Heating surface in use		22,103.8	
Grate surface in use		684.8	
Square feet total H.S. per total I.H.P		1.849	
I.H.P. per square foot grate surface, total		17.45	
ton machinery (penalty weight)		10.64	
Kind of coal		New River (picked).	
Pounds per hour, total		28,209.5	
I.H.P., all machinery		2.36	
main engine, auxiliary, circulating and feed pump		2.39	
square foot grate surface		41.18	
heating surface		1.276	

NUMBER OF WATER TIGHT DOORS, HATCHES ETC.

LOCATION — DESIGNATION	SD	WT	ED	CD	ND	AT	FM	AH	RH	ATH	AS	NH	A	ES	BM	RM	LM	FM	CT	TS	LT	DL	HL	AP	PC	AC	AM	TOTAL
UPPER DECK		13										3	2							34		46					4	102
MAIN DECK		8			20				14	8		3	12	14				2		32	30	47		6		4		206
BERTH DECK		50		17	4	14	10	2	10		18		8					16	18	19	54		45	38				302
PROTECTIVE DECK		4							12		6		2					1						38				63
SPLINTER DECK		85	14	26						20			6	10	3				20	18	32		10					244
PLATFORM DECK		36	2	6		4				21					1	1	1		8				10					90
HOLD	21	91	0		1	11											38	24	2									128
DOUBLE BOTTOM																												
TOTAL	21	225	22	49	25	29	10	16	65	8	24	6	30	24	4	39	65	21	48	107	116	93	20	52	76	4	4	1158

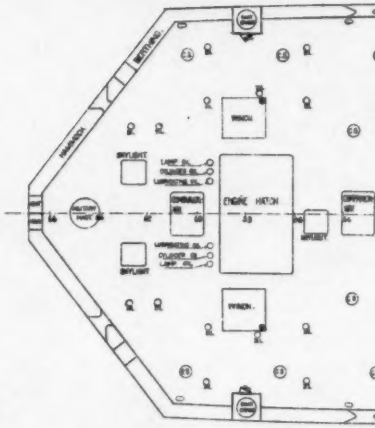
NUMBER OF VALVES ETC

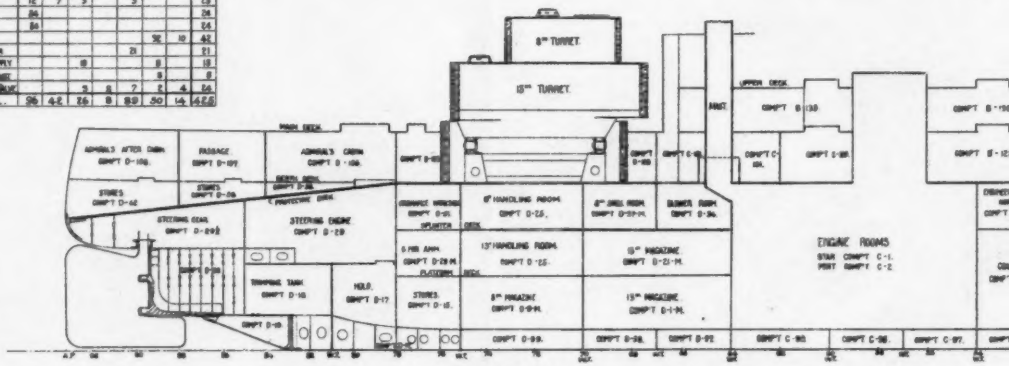
MARK	NAME	WORKED FROM: HOLD	FLAT	SPLINT	PROT	BERTH	MAIN	UPPER	TOTAL
①	DRAIN VALVE	80				6			86
②	SLUICE VALVE	2	2	4		10			18
③	SEA VALVE	8	2						10
④	FLOOD COCK	23	18	3		40			84
⑤	PUMP SUCTION	7	2						9
⑥	OUTER WING DRAIN	14							14
⑦	FLOOR DRAIN		11	3		2			16
⑧	SOUNDING TUBE	12	7	3		3			25
⑨	AIR ESCAPE	24							24
○	MISCELLANEOUS	24							24
▭	SCUPPER						32	10	42
⊠	HORIZON. SLIDING W.T. DOOR					21			21
⊗	VENTILATION NATURAL SUPPLY			18			8		19
⊕	" " EXHAUST						8		8
●	FLOOR DRAIN WITHOUT VALVE			3	8	7	2	4	24
	TOTAL	216	42	26	8	89	50	14	462

NOTE:- 1. THE FOLLOWING W.T. DOORS ARE WORKED FROM ONE SIDE ONLY - HERE 40-41, 2147, 2.54, 2.58, 2.68, 2.69 AND ALL DOORS ON UPPER DECK.

NO. 2. THE FOLLOWING W.T. DOORS IN COAL TRUNKS ARE WORKED FROM EITHER SIDE. NOS 16, 117, 123, 109, 144, 145, 138, 137.

NO. 3. THE ARMOURED HATCHES BETWEEN FRAMES 104-116-117, 1718, 2.5-55, AND FRAMES 67 AND 68 ARE WORKED FROM ABOVE AND BELOW.

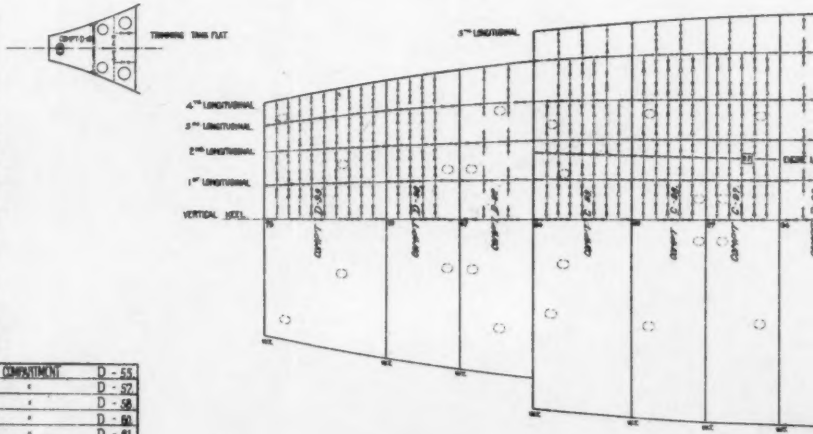


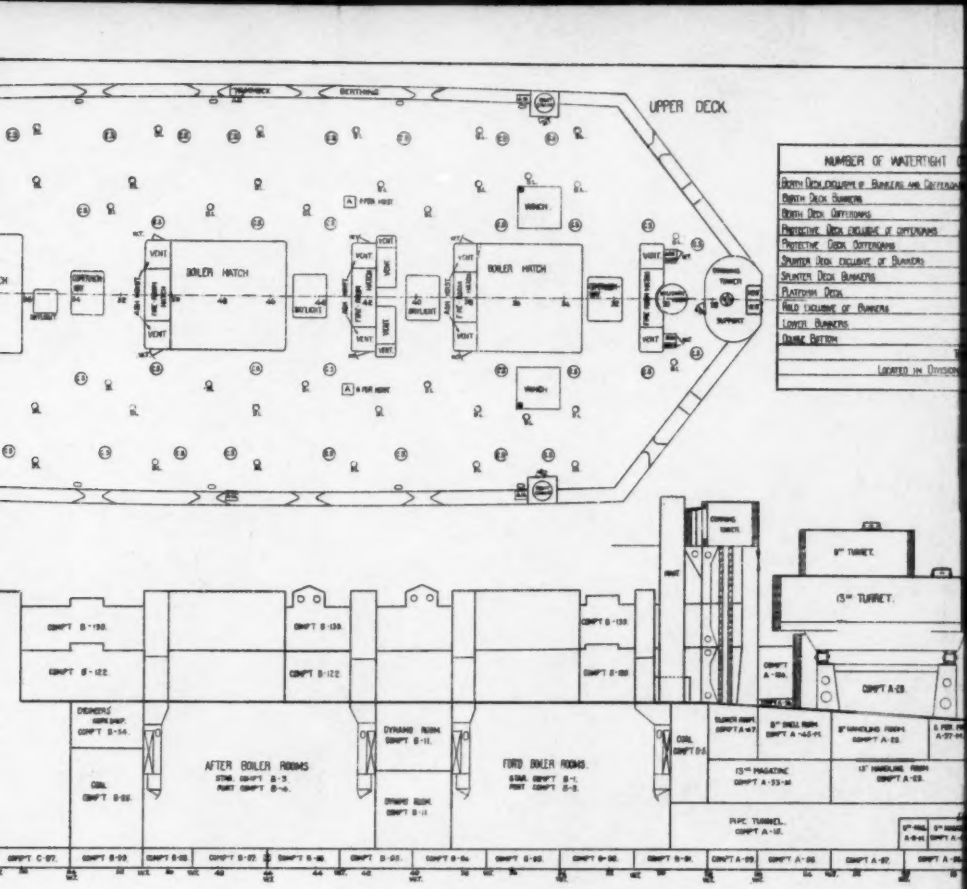


THE FOLLOWING COMPARTMENTS ARE PACKED WITH CELLULOSE AND SHOULD NOT BE OPENED WITHOUT SPECIAL INSTRUCTIONS.

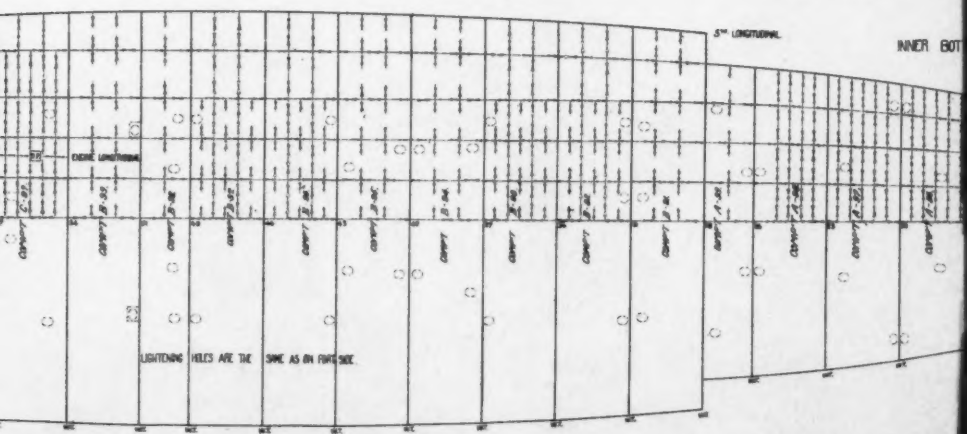
COMPARTMENT		COMPARTMENT	
"	A - 54	"	B - 125
"	A - 55	"	B - 126
"	A - 57	"	B - 127
"	A - 58	"	B - 128
"	A - 80	"	B - 129
"	A - 81	"	B - 133
"	A - 84	"	B - 134
"	A - 86	"	B - 135
"	A - 87	"	B - 136
"	A - 88	"	B - 137
"	A - 105	"	B - 138
"	A - 106	"	C - 102
"	A - 109	"	C - 103
"	B - 106	"	C - 106
"	B - 105	"	D - 101
"	B - 106	"	D - 101A
"	B - 107	"	D - 102
"	B - 108	"	D - 102A
"	B - 108	"	D - 106
"	B - 116	"	D - 106A
"	B - 117	"	D - 106B
"	B - 118	"	D - 105
"	B - 119	"	D - 105A
"	B - 120	"	D - 105B
"	B - 121	"	D - 54
"	B - 150	TOTAL NUMBER OF COMPARTMENTS = 56.	

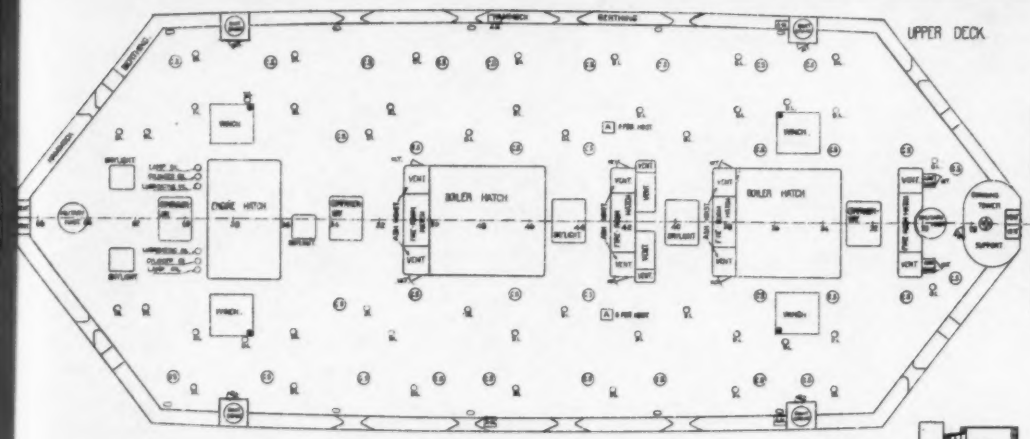
COMPARTMENT	
"	D - 55
"	D - 57
"	D - 58
"	D - 80
"	D - 81




UPPER DECK
BOILER HATCH
BOILER HATCH
WINCH
WINCH
NUMBER OF WATERTIGHT
Located in Division

9" TURRET
13.5" TURRET
CMPT A-69
AFTER BOILER ROOMS
FWD BOILER ROOMS
PIPE TUNNEL
CMPT A-12


5" LONGITUDINAL
INNER BOT
LIGHTENING HOLES ARE THE SAME AS ON PORT SIDE.


UPPER DECK
ENGINE HATCH
BOILER HATCH
BOILER HATCH
WINCH
WINCH
WINCH
WINCH
SKYLIGHT
SKYLIGHT
SKYLIGHT
SKYLIGHT
VENT
VENT
VENT
VENT
VENT
VENT
VENT
VENT
VENT
VENT
VENT
VENT
A FIRE HOSE
A FIRE HOSE
COMPANION WAY
COMPANION WAY
COMPANION WAY
COMPANION WAY
COMPANION WAY
COMPANION WAY
COMPANION TOWER
SUPPORT
WINDLASS
WINDLASS
CAPSTAN
CAPSTAN
CAPSTAN

— THE SYSTEM OF NUMBERING WATERTIGHT COMPARTMENTS —

EACH COMPARTMENT BETWEEN THE SIDES AND THE FORWARD TRANSVERSE BULKHEAD OF THE FORWARD BOILER COMPARTMENT IS DESIGNATED BY THE LETTER A AND A NUMBER; THUS, A-4.

EACH COMPARTMENT BETWEEN THE FORWARD TRANSVERSE BULKHEAD OF THE FORWARD BOILER COMPARTMENT AND THE AFTER TRANSVERSE BULKHEAD OF THE AFTER BOILER COMPARTMENT IS DESIGNATED BY THE LETTER B AND A NUMBER; THUS B-7.

EACH COMPARTMENT BETWEEN THE AFTER TRANSVERSE BULKHEAD OF THE AFTER BOILER COMPARTMENT AND THE AFTER TRANSVERSE BULKHEAD OF THE ENGINE COMPARTMENT IS DESIGNATED BY THE LETTER C AND A NUMBER; THUS, C-1.

EACH COMPARTMENT BETWEEN THE AFTER TRANSVERSE BULKHEAD OF THE ENGINE COMPARTMENT AND THE SIDES OF THE SHIP IS DESIGNATED BY THE LETTER D AND A NUMBER; THUS, D-3.

THE FOUR PRINCIPAL DIVISIONS OF THE SHIP ARE THEREFORE DESIGNATED BY THE LETTERS A B C AND D.

IN EACH DIVISION THE COMPARTMENTS BELOW THE BERTH DECK BUT ABOVE THE INNER BOTTOM ARE NUMBERED CONSECUTIVELY COMMENCING WITH THE LOWEST COMPARTMENT AND NUMBERING FROM FORWARD TO AFT BEGINNING WITH NO 1 TO THE END OF THE DIVISION, WHEN PASSING IN THE NEXT DECK ABOVE AND CONTINUING THE NUMBERING FROM FORWARD TO AFT AGAIN.

ABOVE THE BERTH DECK THE FORWARD COMPARTMENT IN EACH DIVISION IS NUMBERED 100 AND THE OTHER COMPARTMENTS ARE NUMBERED CONSECUTIVELY FROM FORWARD TO AFT TO THE END OF THE DIVISION.

THE DOUBLE BOTTOM COMPARTMENTS IN EACH DIVISION ARE NUMBERED CONSECUTIVELY FROM AFT TO FORWARD BEGINNING WITH THE NUMBER 99.

A COMPARTMENT EXTENDING ACROSS A DIVISION BULKHEAD IS NUMBERED AS THOUGH LOCATED ENTIRELY WITHIN THE FORWARD DIVISION.

WHERE COMPARTMENTS ARE SIMILARLY SITUATED WITH REGARD TO THE MIDDLE LINE ODD NUMBERS ARE ASSIGNED TO THE STARBOARD AND EVEN NUMBERS TO THE PORT COMPARTMENTS.

MACHINERY SPACES HAVING TWO OR MORE COMPARTMENTS ARE STATED FROM THE LETTER M AFTER THE NUMBER OF THE COMPARTMENT, THUS D-3-M.

THE FOLLOWING PRINCIPAL COMPARTMENTS HAVE THE SAME DESIGNATION IN ALL SHIPS: THE BOILER COMPARTMENTS ARE B-6 B-8 B-10 C-1 THE ENGINE COMPARTMENTS ARE C-5 C-7 C-9.

THE NUMBER OF THE COMPARTMENT WILL ALWAYS BE PREFIXED WITH THE LETTER INDICATING THE PRINCIPAL DIVISION OF THE SHIP IN WHICH THE COMPARTMENT IS LOCATED; THUS, A 99 B-2 C 99 ETC.

HOSE NUMBERS 100 OR ABOVE INDICATE COMPARTMENTS ABOVE THE BERTH DECK.

NUMBERS 99 AND UNDER BUT ANY OF THE HOSE NUMBERS BEGIN 100 INDICATE COMPARTMENTS IN THE DOUBLE BOTTOM

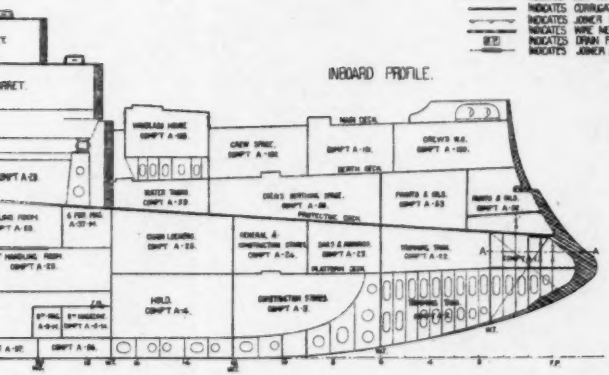
NUMBERS 101 OR ABOVE BUT ANY OF THE LOWER NUMBERS INDICATE COMPARTMENTS ABOVE THE DOUBLE BOTTOM BUT BELOW THE BERTH DECK.

OF WATERTIGHT COMPARTMENTS

BULKHEADS AND COFFERDAMS	6	2	2	5	15
		8			8
	3	26	3	10	42
OF COFFERDAMS	7			5	12
ERDAMS	12			6	18
OF BUNKERS	15	22	8	17	60
		10	2		12
	15			14	29
NERS	19	14	8	22	63
		12	2		14
	4	8	3	3	18
TOTAL	84	103	28	80	292
LOCATED IN DIVISION	A	B	C	D	TOTAL

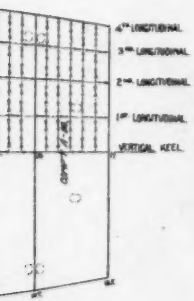
INDICATES W.T. BULKHEADS, FLOORS, ETC.
INDICATES NON W.T. PARTITIONS.
INDICATES CORRUGATED PARTITIONS
INDICATES JOINER PARTITIONS
INDICATES WIRE MESH PARTITIONS
INDICATES DRAIN POCKET
INDICATES JOINER DOORS.

INBOARD PROFILE.



SECTION THRU A-A.

INNER BOTTOM



PLAN NO. 29 A.

U.S.S. KEARSARGE AND KENTUCKY.

BATTLE SHIPS NOS. 5 AND 6.

COMPARTMENT AND ACCESS PLAN.

UPPER DECK, INBOARD PROFILE AND INNER BOTTOM.

SCALE - 1/8 INCH = 1 FOOT. TAKEN FROM WORK.

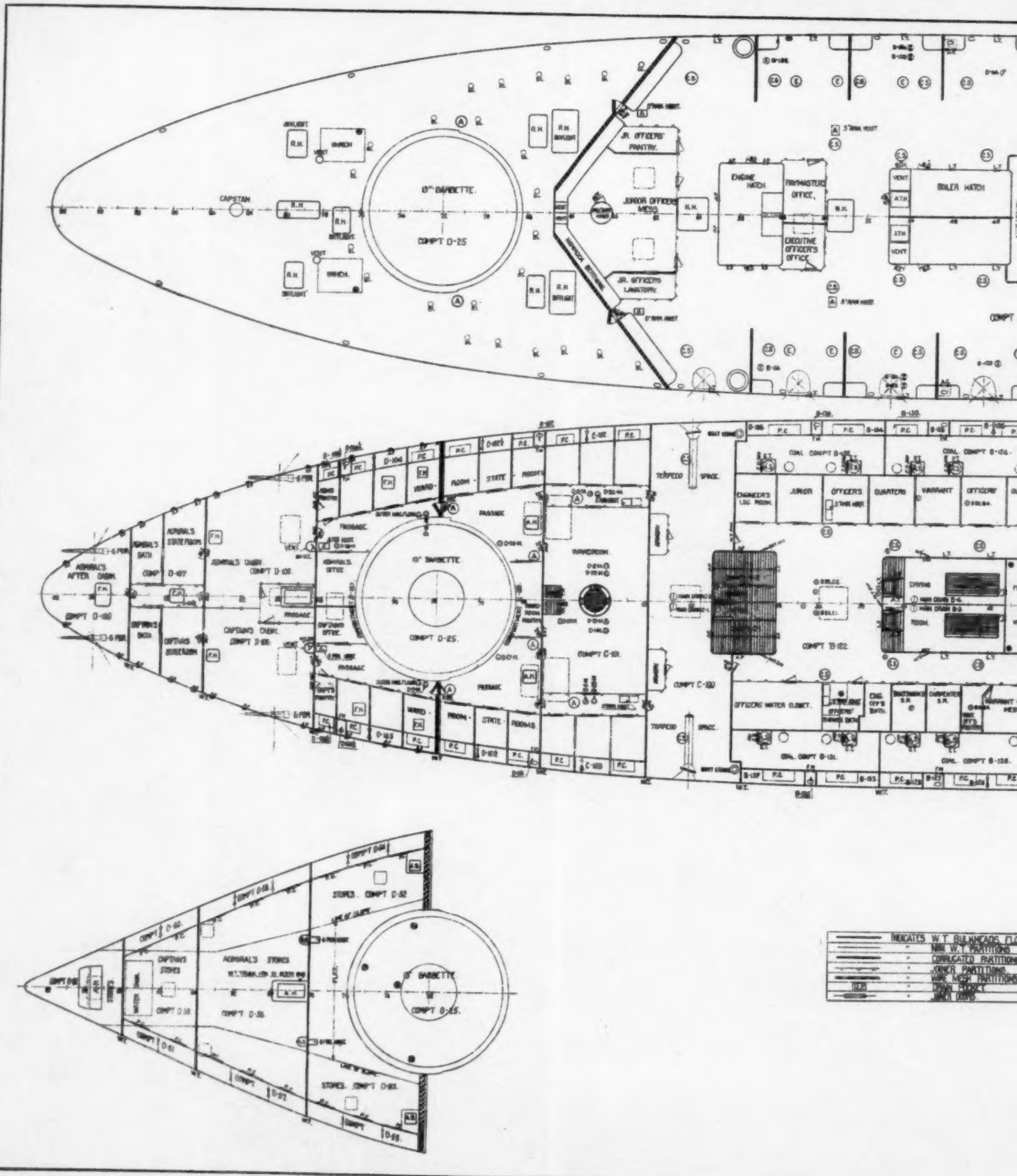
Office of the Superintending Engineer for the U.S. Navy, NEWPORT NEWS SHIPBUILDING CO. Newport News, Va.

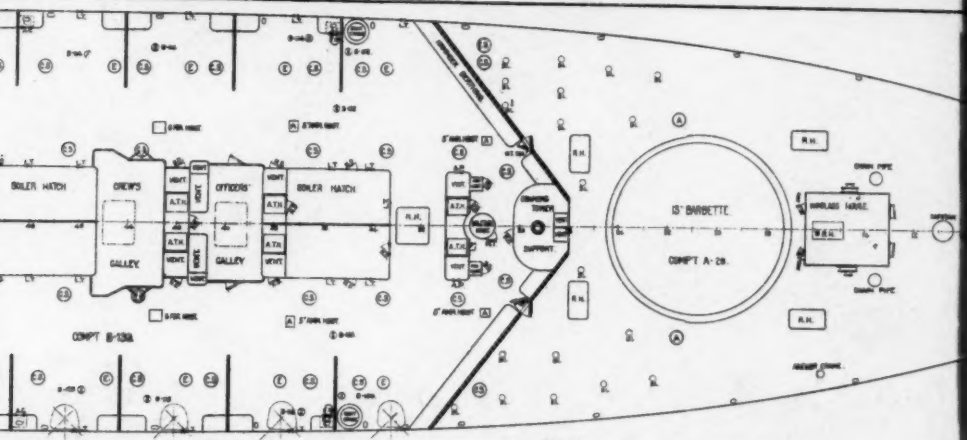
Remember only Letter No. ____

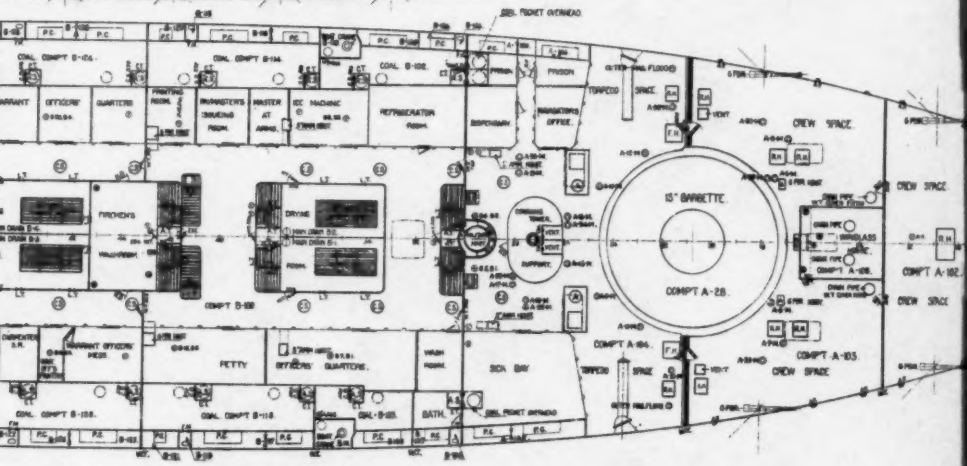
Naval Constructor U.S.N. Superintending Constructor

DRAUGHTSMANS STAMP
Newport News No. Sept. 6th 1898
In Charge of Work
Subject F.B. WHITAKER.
Traced by F.B. WHITAKER.

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

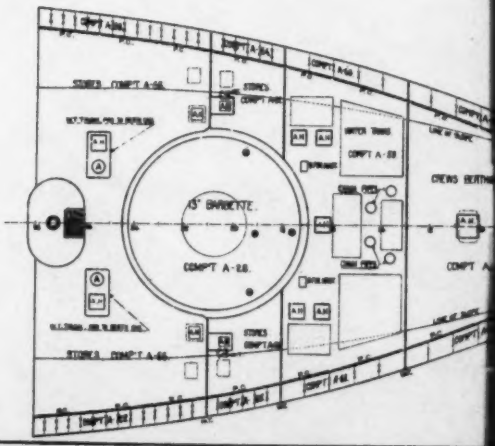

CAPSTAN
WINCH
SKYLIGHT
VENT
R.H.
COMPT D-25
JR. OFFICERS' PANTRY
JUNIOR OFFICERS MESS
JR. OFFICERS LAVATORY
ENGINE HATCH
PAYMASTER'S OFFICE,
EXECUTIVE OFFICER'S OFFICE
BOILER HATCH
ATH
ADMIRAL'S AFTER CABIN
COMPT D-100
ADMIRALS BATH
ADMIRALS STATEROOM
CAPTAINS BATH
PASSAGE
ADMIRALS OFFICE
CAPTAINS OFFICE
WARD-ROOM STATE ROOMS
WARDROOM
COMPT C-101
TORPEDO SPACE
COMPT C-100
ENGINEER'S LOG ROOM
JUNIOR OFFICERS QUARTERS
WARRANT OFFICERS'
DYNAMO ROOM
COMPT B-122
OFFICERS WATER CLOSET
CARPENTER S.R.
COAL COMPT B-124
COAL COMPT B-131
COAL COMPT B-126
CAPTAINS STORES
ADMIRAL'S STORES
WATER TANK
STORES
FLAT
COMPT D-56
STORES. COMPT D-52
STORES. COMPT D-83
INDICATES W.T. BULKHEADS
NON W.T. PARTITIONS
CORRUGATED PARTITIONS
JOINER PARTITIONS
WIRE MESH PARTITIONS

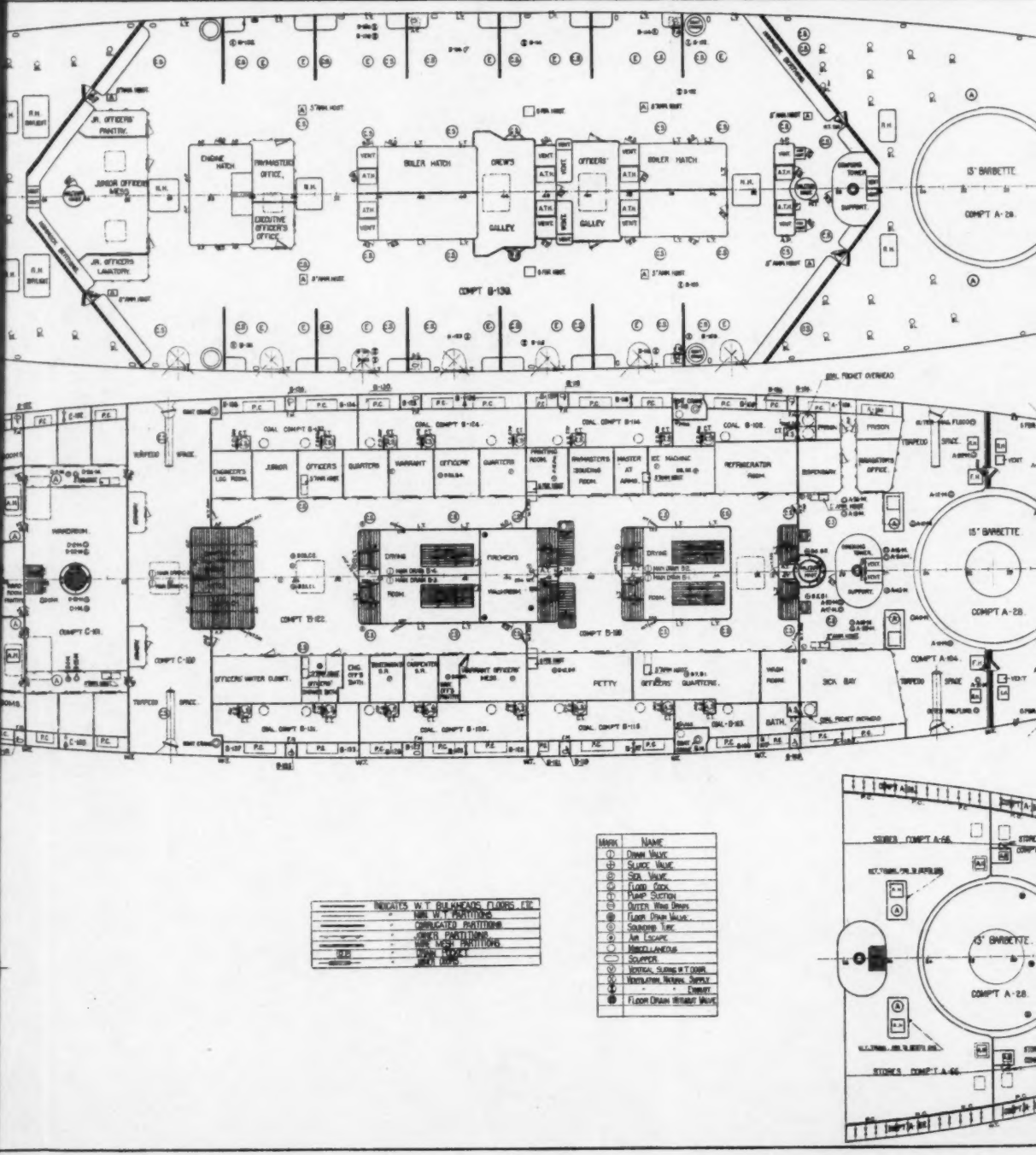




W.T. BULKHEADS, FLOORS ETC.
NON W.T. PARTITIONS
CORRUGATED PARTITIONS
WIRE MESH PARTITIONS
WIRE LOCK PARTITIONS
IRON DOORS
SLIDING DOORS

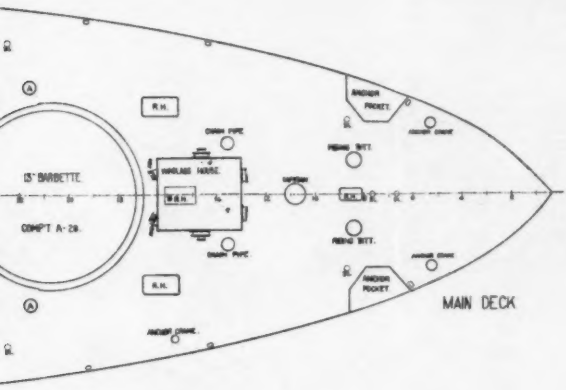
MARK	NAME
	DRAIN VALVE
	SUCTION VALVE
	SEA VALVE
	FLOOD COCK
	PUMP SUCTION
	OUTER WING DRAIN
	FLOOR DRAIN VALVE
	SOUNDING TUBE
	AIR ESCAPE
	MANGO-LANZONE
	SCUPPER
	VERTICAL SLIDING W.T DOOR
	VENTILATION NATURAL SUPPLY
	" " EXHAUST
	FLOOR DRAIN WITHOUT VALVE

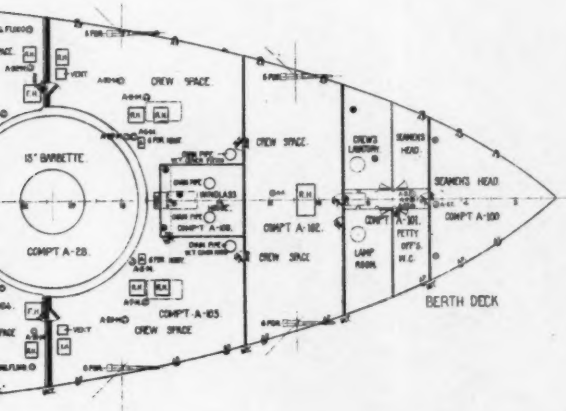


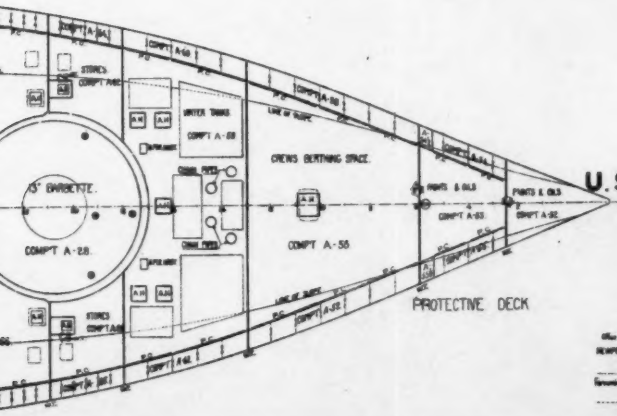


	INDICATES W.T. BULKHEADS, FLOORS ETC.
	" W.T. PARTITIONS
	" CORRUGATED PARTITIONS
	" JOINER PARTITIONS
	" NON W.T. PARTITIONS
	" DOORS
	" HATCHES
	" SLIDING DOORS

MARK	NAME
	DRAIN VALVE
	SLUICE VALVE
	SEA VALVE
	FLOOD COCK
	PUMP SUCTION
	OUTER WASH DRAIN
	FLOOR DRAIN VALVE
	SOUNDING TUBE
	AIR ESCAPE
	MISCELLANEOUS
	SCUPPER
	VERTICAL SLIDING W.T. DOOR
	VENTILATION, NATURAL SUPPLY
	" EXHAUST
	FLOOR DRAIN WITHOUT VALVE







S.D.	VERTICAL SLIDING W.T. DOOR.
W.T.	ARMORED FROM HOLD OR BERTH DK. ARMORED W.T. DOOR. ARMORED FROM OTHER SIDE.
E.D.	W.T. ESCAPE DOOR.
C.D.	W.T. DOOR IN COAL TRUNK.
N.D.	RIVETED NON W.T. METAL DOOR.
A.T.	AIR TIGHT METAL DOOR.
F.H.	FLUSH W.T. HATCH.
A.H.	ARMORED W.T. HATCH.
R.H.	RAISED COAMING W.T. HATCH.
A.T.H.	AIR TIGHT HATCH.
A.S.	SIL ARMORED W.T. SCUTTLE.
N.H.	NON W.T. HATCH.
A.	W.T. AMMUNITION SCUTTLE.
E.S.	W.T. ESCAPE SCUTTLE.
B.M.	W.T. MANHOLE IN BULKHEAD.
R.M.	RAISED W.T. MANHOLE.
F.M.	FLUSH W.T. MANHOLE.
C.T.	W.T. COAL TRUNK.
C.S.	W.T. COAL SCUTTLE.
L.T.	W.T. DECK LIGHT.
D.L.	W.T. DECK LIGHT.
M.L.	W.T. CAGED 16 NAC LIGHT BOX.
A.P.	HINGED W.T. ROUND AIR PORT.
L.M.	LOW W.T. MANHOLE.
P.C.	PORTABLE COVER W.T.
A.C.	W.T. ASH CHUTE DOOR.

PLAN NO. 29 A-1.

U.S.S. KEARSARGE AND KENTU

BATTLE SHIPS NOS. 5 AND 6.

COMPARTMENT AND ACCESS PLAN.

MAIN, BERTH, AND PROTECTIVE DECKS.

SCALE - 1/8 INCH = 1 FOOT.

TAKEN FROM WORK

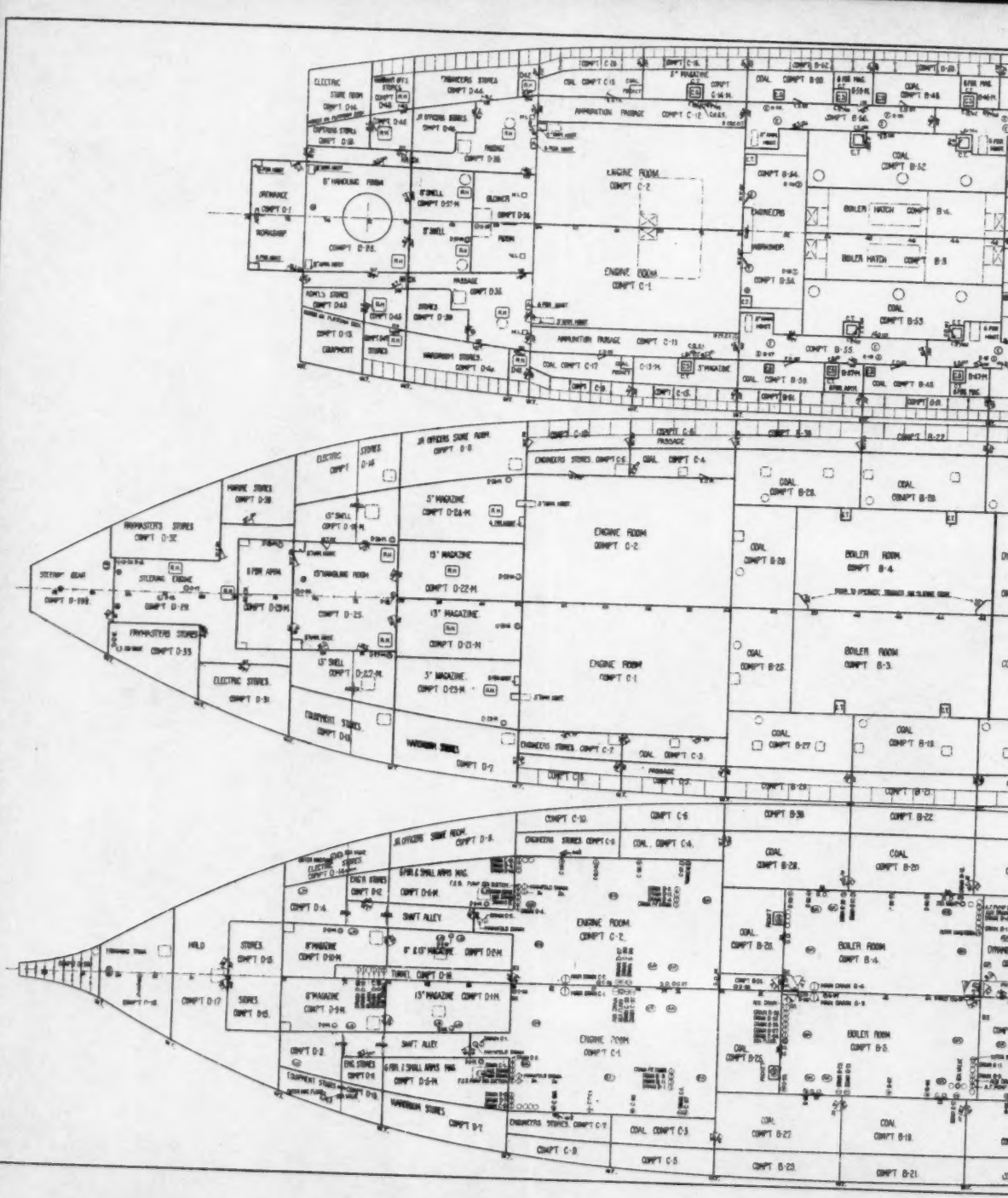
Office of the Superintending Constructor for the U.S. Navy, NEWPORT NEWS SHIPBUILDING CO. Newport News Va.

Contract with Letter No.

Supervising Constructor U.S.N.

DRAUGHTSMAN Newport News Va. In Charge of Work Submitted Traced by

THE HORRIS PETERS CO., PHOTO-LITHO., WASH


ENGINE ROOM
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ENGINE ROOM
COMPT C-1
BOILER ROOM
COMPT B-4
BOILER ROOM
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BOILER ROOM
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ENGINEERS STORES COMPT C-7
ENGINEERS STORES COMPT C-8
ENGINEERS STORES COMPT C-9
ELECTRIC STORE ROOM
ELECTRIC STORES
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EQUIPMENT STORES
SHAFT ALLEY
TUNNEL
PASSAGE
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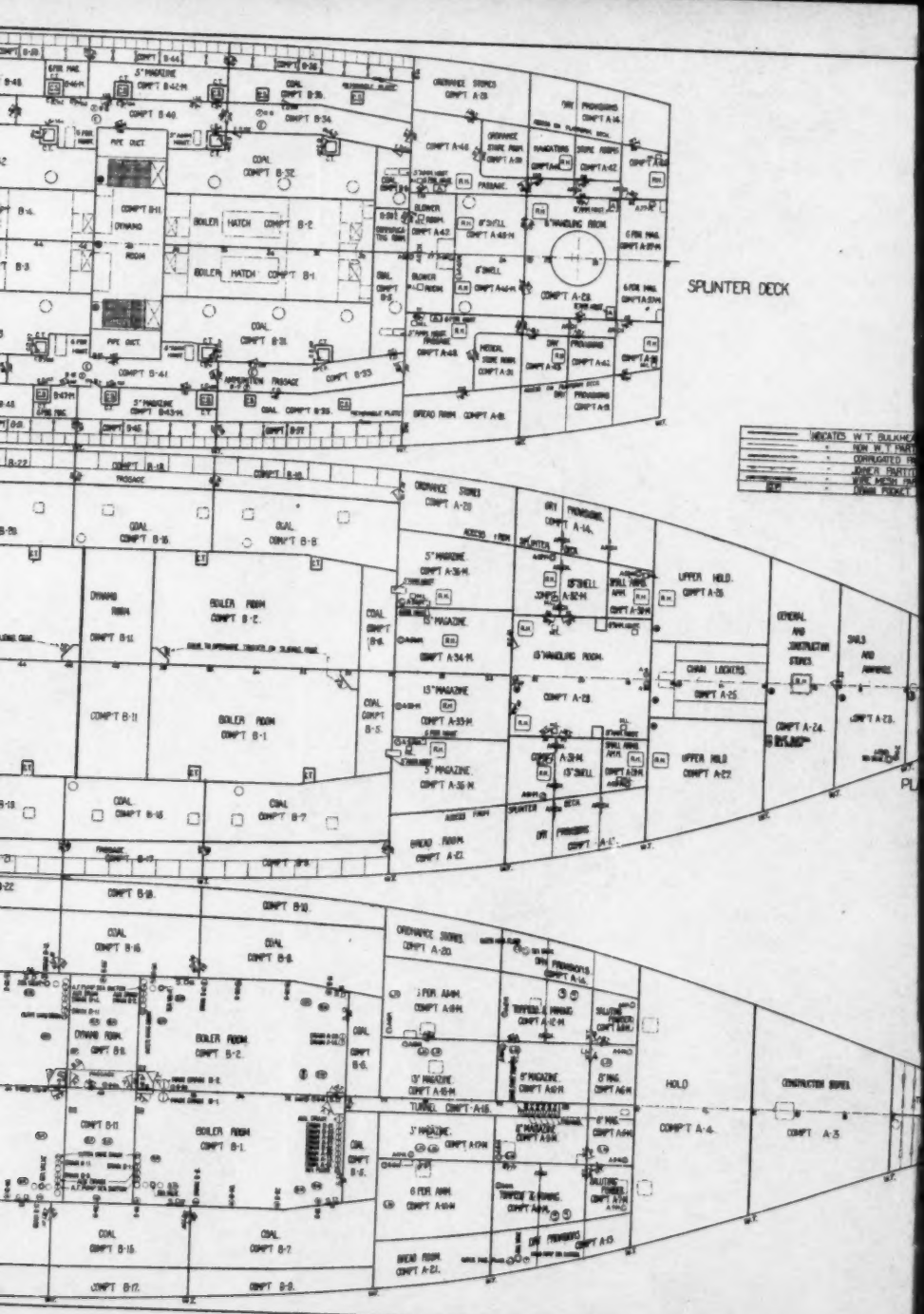
BOILER ROOM
COAL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COMPT A-4
COMPT A-5
HOLD
CONSTRUCTOR STORES
UPPER HOLD
COMPT A-22
COMPT A-23
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COMPT A-26
CHAIN LOCKERS
15" HANDLING ROOM
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BREAD ROOM
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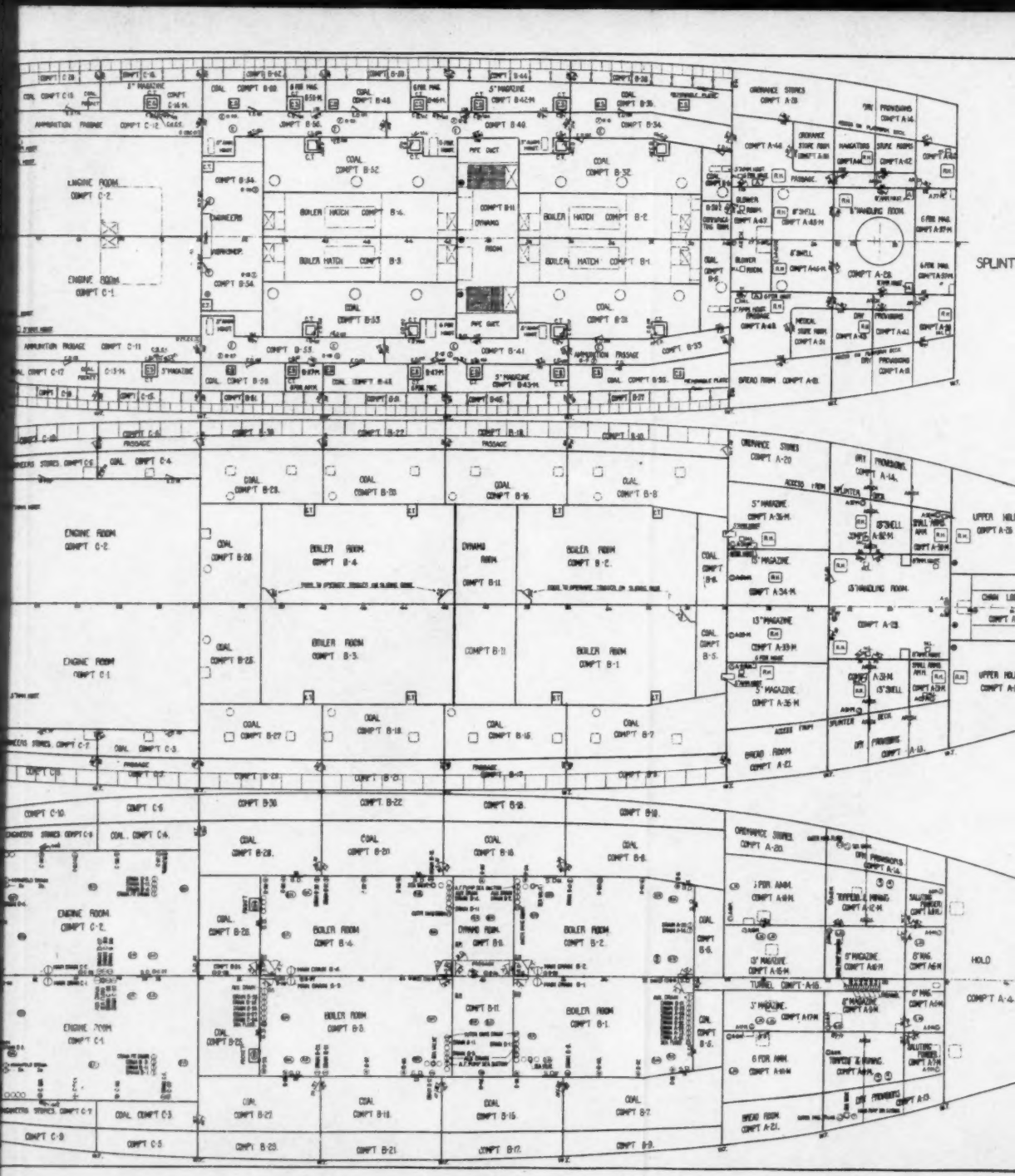
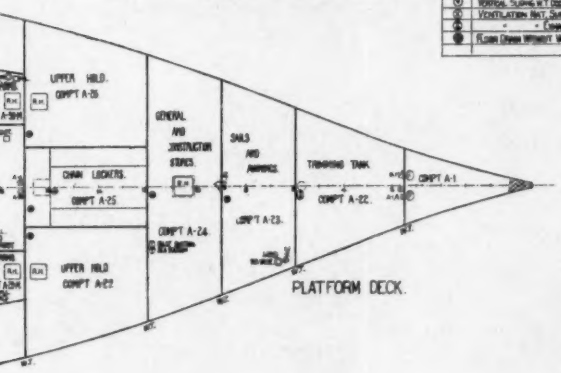

ENGINE ROOM
BOILER ROOM
DYNAMO ROOM
COAL
SPLINT

SPLINTER DECK

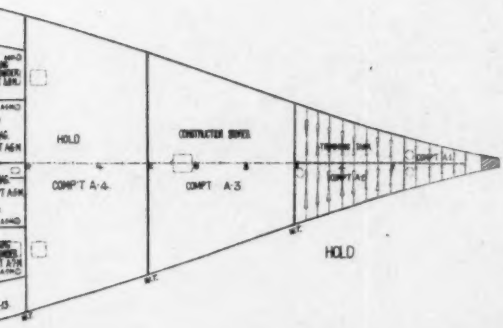
	INDICATES W.T. BULKHEADS FLOORS, ETC.
	" NON W.T. PARTITIONS
	" CORRUGATED PARTITIONS
	" JOINER PARTITIONS
	" WIRE MESH PARTITIONS
D.M.	" DRAIN PIPE ET

Mark.	Name
	Drain Valve
	Sluice Valve
	Sea Valve
	Flood Cock
	Pump Suction
	Outer Wing Drain
	Floor Drain
	Sounding Tube
	Air Escape
	Miscellaneous
	Scupper
	Vertical Sliding W.T. Door
	Ventilation Nat. Supply.
	" " Channel
	Floor Drain without Valve

S.D.	VERTICAL SLIDING W.T. DOOR
W.T.	HINGED W.T. DOOR HINGED FROM EITHER SIDE
E.D.	W.T. ESCAPE DOOR
C.D.	W.T. DOOR IN COAL TRUNK.
N.D.	HINGED NON W.T. METAL DOOR.
A.T.	AIR TIGHT METAL DOOR
F.H.	FLUSH W.T. HATCH
A.H.	ARMORED W.T. HATCH
R.H.	RAISED COAMING W.T. HATCH
A.T.H.	AIR TIGHT HATCH
A.S.	SKYLARMORED W.T. SHUTTER.
N.H.	NON W.T. HATCH
A	W.T. ARMOURTEN SCUTTLE.
E.S.	W.T. ESCAPE SCUTTLE.
B.M.	W.T. MANHOLE IN BULKHEAD
R.M.	RAISED W.T. MANHOLE.
F.M.	FLUSH W.T. MANHOLE.
C.T.	W.T. COAL TRUNK.
C.S.	W.T. COAL SCUTTLE.
L.T.	W.T. DECK LIGHT.
D.L.	W.T. DECK LIGHT
M.L.	W.T. COVER TO MAG. LIGHT
A.P.	HINGED W.T. ROUND AIR PORT.
L.M.	LOW W.T. MANHOLE
P.C.	PORTABLE COVER W.T.



PLATFORM DECK.



HOLD

PLAN NO. 29.A-2.

U.S.S. KEARSARGE AND KENTUCKY.

BATTLE SHIPS NOS. 5 AND 6.

COMPARTMENT AND ACCESS PLAN.

SPLINTER DECK, PLATFORM DECK AND HOLD.

SCALE - 1/8 INCH = 1 FOOT. TAKEN FROM WORK.

Office of the Superintending Constructor
U.S. Battle Ships
NEWPORT NEWS SHIPBUILDING CO.
Newport News, Va.

Forwarded with letter of

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Superintending Constructor.

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THE HORNING PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

THE ANNUAL REPORT OF THE ENGINEER-IN-CHIEF.

There is so much important matter in Admiral Melville's report this year as to make it advisable to reprint in our pages a considerable portion of it, especially as so many of our associates and subscribers never obtain more than the synopses of Bureau annuals as are printed with more or less fullness in the current press.

It is well for our Society to have a clear idea of the extent and importance of the technical work of the Bureau of Steam Engineering, particularly at a time when considerable publicity has been given to schemes for the combination of the "working bureaus" of the Navy—these being understood as including the Bureaus of Steam Engineering, Equipment, Ordnance, and Construction and Repair. That such a combination is antagonistic to efficiency, as understood by the outside shipbuilding world, goes without saying, but, nevertheless, the full scope of the actual work of each bureau is known to far too few of those who take interest in general naval engineering.

Besides detailing this work Admiral Melville significantly touches on the questionable points in the operation of the Personnel Bill, and also takes up, in extenso, the subject of electrically-driven auxiliaries on ship board. This latter section has called forth some editorial criticisms from the "Electrical World," which appear to us to be cynicism born of disbelief in the Personnel Bill rather than any refutation of the statements of the Engineer-in-Chief.

Interesting data of tests of machinery, etc., are given, and the report includes several plates of proposed machinery for the new cruisers, 14 to 19, which we are unable to reproduce at this time.

The following extracts contain the most important parts of the report.

GENERAL OPERATIONS OF THE BUREAU.

While the legislation of the last Congress provided for an increase of the Navy by appropriating for three seagoing coast-line battleships, three armored cruisers and six protected cruisers, the limitations placed upon the price of the armor and the clause which prevented contracts being made for the hull until the armor for the first two classes of the above vessels had been contracted for, presented insuperable obstacles in the way of proceeding promptly with the building of the same, the price of armor mentioned in the bill being far below that for which any manufacturer would deliver it.

On this account the immediately necessary designing work in this Bureau upon new ships was confined to plans for the machinery for the six protected cruisers, as will be noted under the head of work in the drawing room.

Plans of general arrangement of machinery for the armored cruisers, however, have been pursued to such a degree as is warranted by the available outlines, so that when the matter of cost of armor is adjusted and further progress of plans justified the completion of the designs will be a matter requiring but little time.

The usual extensive and laborious duty connected with the working out of details for machinery already under construction, and the examination and correction of designs submitted by contractors, have been continued in a manner highly satisfactory in results. The matter of designing the internal arrangements of machine shops at New York, Port Royal, Key West and Mare Island has also demanded considerable attention, in order to provide for the most efficient disposition of tools when installed.

In my last annual report I alluded to the extraordinary conditions which were then prevailing, and included the general items of importance in the machinery-repair work of this Bureau up to the date of writing that report, October 1, 1898, at which time the cessation of hostilities had about taken effect. Necessarily the results of the extraordinary duties of the various ships under such circumstances were not fully realized by the Bureau until the return of the fleets to the repair stations, but it was a matter

of gratifying surprise to the Bureau to find the extent of needed repairs as limited as it was, being generally confined to portions of the machinery such as boiler tubes and condenser tubes, which are most readily affected by the extreme conditions prevailing in war times. The generally excellent condition of the engines of our ships after these trials is a reflection of a highly complimentary character upon the Bureau's control of the designs of the machinery and upon the efficiency of the officers under whose direct charge their operations were conducted.

The matter of completely repairing all the ships, both of the regularly Navy and those retained from the auxiliary fleet, was taken promptly in hand as ships returned to the various yards, and the aggregate cost assumed small proportions compared with what might have been anticipated. Most of this work has now been effected, and yet, owing to the unexpected retention of very many of the auxiliary ships for use in naval service, the estimates made by the Bureau in the last annual report for current expenses, 1899–1900, fell far short of the amount actually required, as at the time of the report it was the general impression that upon the close of the war most of the auxiliary ships would be sold or otherwise disposed of. A portion of the large balance remaining in the Treasury from the emergency fund under this Bureau (between two and three millions) could be very properly reappropriated for this unanticipated work, by special legislation, and obviate the necessity of asking for further provision for current work in the coming deficiency bill. I desire to call your attention to the above circumstances in view of the necessity of thus further providing for the expenses of the present fiscal year.

The general lessons from the war were in no way indicative of any desirable change in the machinery of our ships, with the exception of increasing the evaporating plants, and the adoption, with all practical and economical promptness, of the water-tube type of boilers. . The matter of increasing the evaporating plants has been expeditiously accomplished, and at present these individual plants on shipboard are about equal to any anticipated emergency. As regards the adoption of the water-tube type of boiler, the Bureau is progressing with such proper speed as is

necessary to avoid mistakes, and to obviate sacrifice of still useful boilers of the older type. As fast as the present outfit of Scotch boilers becomes unreliable or inefficient, the newer type is being substituted. This has obtained already on the *Alert*, *Atlanta* and *Chicago*, and a further substitution of Babcock & Wilcox type of water-tube boilers for the old Scotch boilers on the *Cincinnati* and *Raleigh* is in active progress. These steps are important and are the direct results of the unqualified success of this type of boiler on the *Marietta* and *Annapolis* in our own service and on various other ships not of the Navy, and renders their adoption, to the extent already made, absolutely safe. Much interest also attaches itself not only to the trials of the battleships now building, which will have the Niclausse and Thorncroft types of water-tube boilers, but especially to the future preservation of the several types of these boilers during the years of that ordinary naval service which will not call for more than a very limited use of the entire plant. The status of water-tube boilers at the present time is much more doubtful regarding the possibilities of protection from deterioration while not in use than regarding their efficient output during actual service. This ability or inability to properly protect such boilers is of most vital importance, and largely governs the annual cost of repairs to naval machinery.

I would call attention to the completion of the *Rainbow* as a second distilling ship and also to the success with which the *Iris*, the first distilling ship, has been operated. This latter is noted under its separate heading in this report.

While not desiring to allude prominently again to the *Vulcan* or its work as a repair ship (the subject having been fully exhausted in my last report and in the public periodicals), I can not pass this by without again urging the advisability of properly designing and building a repair ship, which, while being constructed with a view to the utmost efficiency for such service in times of emergency, may be retained without use (in ordinary) and without serious deterioration for many years. The promptness with which the *Vulcan* was fitted up during the first excitement of the war does not indicate that a waiting policy is the wisest one, for

by accident alone the absolutely necessary work demanded of that ship was well within her capacity. There is no good reason for failing to provide a ship which would be even far more efficient than the *Vulcan* was and one perfectly self-sustaining in any climate or location. The *Vulcan* herself proved to be of but temporary fitness, as, after the war, the hull was found to be in such bad condition as to make it proper to strip the vessel and effect her sale.

During the year a number of torpedo boats have been completed and turned over to the Government, a synopsis of their trials being herein placed under separate headings.

Among the special items of navy-yard work on naval vessels I would note the following, a complete list of all vessels repaired being included elsewhere under separate yard headings:

Chicago.—Installation of new machinery completed, trials successfully made and ship sent on a regular cruise.

Atlanta.—Reconstruction of machinery and installation of new boilers practically completed, and ready for steam trial.

Cincinnati and *Raleigh.*—Preliminary work on complete rearrangement of fire-room plants and improvements in entire conditions obtainable in machinery spaces. The space originally allotted for the boilers of these two ships was not governed by a full appreciation of the requirements for successfully operating the plant. The limits of the machinery compartments were fixed in a certain arbitrary proportion, and the problem forced upon this Bureau of installing the requisite power to secure a specified speed. This was accomplished only at a sacrifice of operating space, and the well-foreseen results were that the fire rooms were almost unbearably hot under full-power conditions. A change recommended by me and prompted by economy was to remove two auxiliary boilers and spread the remaining boilers to advantage in increasing fire-room space available for working the fires, but the decision of the Board on Construction, now approved, has included a replacement of the entire Scotch boiler plant by water-tube boilers, and, with the increased pressure to be used, new H.P. cylinders are necessitated, of smaller diameter. Undoubtedly the result, while reducing the rated speed of these

ships, will really increase the speed that can be properly maintained, and will greatly add to the efficiency of the vessels.

In powering a ship efficiently, and with a guaranty of securing readily the full I.H.P. of design, the space for machinery must be the primary consideration and a liberal allotment made for it according to the needs, not as gathered from published data of foreign ships (of whose actual working conditions we can never be sure), but from those known to be proper by this Bureau, whose professional experience and knowledge should be accepted without question.

Alert.—Installation of water-tube boilers is well in hand at Mare Island, Cal. The type selected is that of the Babcock & Wilcox Co. A test of one of these particular boilers was made prior to shipment from the works, under the direction of this Bureau and by its own officers, a synopsis of the test being included herein under tests and experiments. The showing was most satisfactory. In this change in the *Alert* it will be seen by the accompanying drawings that a saving in space and weight was made by which the coal capacity was increased by about 32 tons, and at the same time a somewhat greater horsepower was secured, owing to the ability to burn economically more coal upon the new grate surface than was possible upon the grate surface of the old boilers.

Mohican.—Old boilers removed from the *Swatara*, but still in efficient condition, were placed in this vessel, her old boilers having been condemned as worn out in service.

Hartford.—Installation of new machinery very nearly completed at this writing and an early dock trial expected. The work on this and preceding two ships has been done at the navy-yard, Mare Island.

Monterey.—Practical renewal of boilers (caused by pitting of tubes) is in hand. This ship has the Ward type of water-tube boiler, and the renewal in sections can be made without serious difficulty by the engineer force of the ship and without the necessity of tearing up the decks, a feature worthy of notice in connection with several of the types of water-tube boilers now being used by this Bureau.

Iowa.—Complete retubing of boilers and condensers has been carried out.

Also the completion of the retubing of the boilers of the *Minneapolis* was included in the year's work.

The captured ships *Isla de Cuba*, *Isla de Luzon* and *Don Juan de Austria* have had extensive repairs to machinary done at Hongkong under contracts made by the commander-in-chief of the station under the emergency appropriation, and no doubt these vessels will render good service when finished.

In connection with special work, I desire to call your attention to several casualties which have occurred since my last report, in order that there may be no misconception of their import.

The *Wilmington* and *Helena* both have had mishaps to their propeller shafts, which, while not totally disabling the ships, indicate to the Bureau the propriety of installing new outboard shafts of greater strength. A large factor of safety was used in the design, but owing to the small diameter and great length of the outboard sections of these shafts they appear to have been greatly strained, probably more by springing and surging in a seaway than by the normal pressures brought upon them. New shafts are being made for both of these ships and will no doubt prove efficient.

The shafts of the *Marietta* and *Wheeling* have also proven defective through imperfect fitting of casings by the contractors, which permitted corrosion to take effect unseen beneath the brass. The present shafts of these ships are serviceable, but new end sections will be supplied as soon as possible for the *Marietta* in order to secure her against possible casualty, and new end sections for the *Wheeling* are now in the shops at Mare Island being fitted for that vessel.

Another casualty has been reported, viz: that of the cracking of the low-pressure cylinder liner of the port engine of the *Chicago.*

This did not materially disable the ship, although the first dispatches indicated that the low-pressure cylinder would have to be put out of use and the port engine run compound. The

vessel has safely reached a home port, using the cylinder referred to, and necessary repairs will be made after careful examinations.

The after low-pressure cylinder frame of the port engine of the *Cincinnati* was broken while getting the ship under way, but the cause of the accident was not traced by the board which reported upon the same. The engines of this ship are of the four-cylinder, triple-expansion type, and the engines were readily and successfully operated after disconnecting the cylinder whose frame was cracked, so that return to the home port was but slightly delayed. These frames were cast iron.

One of the most serious casualties during the year was that resulting in the destruction by fire of the steam engineering buildings at the navy yard, New York, on February 15, 1899. The only buildings of the plant that were saved were the foundry, copper shop and a part of the boiler shop. It has apparently been impossible to locate the cause of this disastrous fire, but it is with no little pride that the Bureau points to the efficient manner in which its work was continued at that yard. The timely assistance afforded by the permitted use of the shops of other departments in the yard tided over the immediate difficulties, and with the greatest possible dispatch a temporary machine shop was erected on an adjacent lot and installed with such a complete tool outfit as has already enabled the Bureau to withdraw its force from all other shops in the yard and carry on its own work within its own buildings. At the same time all necessary steps were taken for the establishment of a new machinery plant at the yard, for which a prompt appropriation of $750,000 was made by the Congress, then in session. When finished this will undoubtedly be one of the most complete and efficient plants in the world, every advantage being taken of the latest devices of proven excellence.

The Bureau has seen fit to adopt an electrical drive for these shops in view of the advances made in that direction by the most progressive outside establishments, and also paying due attention to the indications of a still more rapid advance in the future. Contracts have been let for the power plant, and a most exhaust-

ive requisition for proper outfit has been formulated after a thorough and extensive individual study of modern tools. In these shops no steam will be used outside of the power house proper, except for heating. The latest pneumatic appliances will also be installed where of established excellence and of economic advantage.

Close inspection of construction of machinery for new ships at the various shipyards has been maintained, and several tests and experiments of interest have been conducted by the Bureau, as noted under separate heading in this report.

PERSONNEL.

I approach the subject of the personnel with some hesitancy, owing to my inability to see indications of the desired result from the operations thus far of the personnel bill. It was my earnest hope that upon the taking effect of that bill the whole trend of detail would be toward the complete amalgamation of line and engineering interests in the Navy with the most favorable outlook for the protection of the rapidly advancing engineering science. My belief in the spirit of the bill was that it contemplated most essentially vast additions to the number of officers who would give earnest attention to engineering matters, and in no way aimed to augment the forces available for merely former line or deck duty. The comprehensive union of the line and engineering vocations I still hope will be the result of the personnel change, and I earnestly request that no Department regulations may be formulated or permitted to exist which will in any degree tend to destroy this belief or prevent such a construction of the intention of the bill. Briefly, the fate of the reconstruction of the personnel hinges upon the provisions made for future and continuous supply of efficient engineers in the Navy. The duties of the line were believed to be perfectly compatible with a professional excellence in engineering matters by an individual. A not unwarranted expectation is that preference for the mechanical part of these combined duties will be shown by a great number owing to the intense interest attaching itself to this field of work and to its almost universal application to the pro-

gressive arts of the age. The only plausible scheme, therefore, is to insist upon the present line officer adapting himself as soon as possible to the new conditions, and increasing, where lacking, his knowledge of mechanical engineering. Primary instruction has already been given to every graduate of the Naval Academy. Necessary practice is easily attained. Departmental regulations insisting upon alternations for the present watch officers in deck and engine-room duties will accomplish the latter end. Efficient and complete instruction at the Naval Academy will enable the future line officer even more rapidly than now to grasp the new work and control it successfully. The practical instruction of the present watch officer, as above suggested, is a fundamental and vitally necessary feature which, in my opinion, should govern the rulings of the Department from now on.

I must invite your particular attention in this connection to the status of steam and mechanical engineering of to-day. Various outcroppings in the shape of electrical, hydraulic and pneumatic specialties divert the thoughtless into considering these fields fundamentally separate from that of steam engineering, while the fact remains that the man educated fully in "steam engineering" is in the very front rank of the advancing workers in such specialties. The principles of the side branches are of extreme simplicity, those governing the construction of the mechanisms being essentially the same as obtain in good mechanical engineering.

It is only necessary to push aside the more or less plausible superficialities which would lead to a misjudgment of these facts, and look for a moment upon the real requirements, to realize how fundamentally important and distinct are the duties of a mechanical bureau, and also to be convinced of the wisdom of using every exertion to provide the highest special talent for its future operation. I regret the matter of combination of bureaus has been even speculated upon. This regret, I assure you, in no way comes from motives other than the belief in the impossibility of a successful issue of such a scheme. Not only is the trend of modern mechanical work in all branches toward increased specialization, but the wisdom of such a trend is never questioned by the leading talent in the outside world of constructive work.

I deem it pertinent in this connection to briefly review the character of the work of this Bureau and to note its increasing extent and importance in all branches.

The first and most important of the duties of the Bureau are those of superintendence of design of new machinery and of improvements to existing plants. The extreme accuracy necessary for and the numberless details attached to the design of modern power plants makes it absolutely requisite to have engineers of experience and ability as personal superintendents. The Bureau has heretofore carefully selected its men for this particular duty, and the results have proven the wisdom of the course pursued as well as the efficiency of these workers.

Following this work, and still pertaining to actual Bureau work, are the duties of overseeing methods of repair and desired improvements to existing machinery; guarding and adjusting the expenditures at the various stations for material and for new tools; developing the qualities of material by constantly studying the improvements in the manufacture of iron and steel and formulating the requirements in specifications, in order to secure to the Government the very best possible material; testing and experimenting with improved devices which give promise of economy, and of collating data by means of which machinery design is improved and work expedited.

The results of preserving this central control of the Bureau's operations are seen in the preservation of uniformity of design and in the adoption generally, in all the repair stations, of the very best methods of work, consequent upon which uniformity great economy to the Government ensues.

Besides this actual Bureau work, it is necessary to have representatives personally superintend the constructive and repair work to the machinery of ships at navy yards and stations. The experienced and educated engineer is nowhere more fitly placed than here. They act as skilled doctors for the disabled elements in the naval establishment, and wherever the guardianship of the Bureau's interests at such places is left to inefficient hands the results are speedily shown in the character of the repairs made. It is in the highest degree economical to have

engineering talent of the highest order at the head of the steam engineering departments at these yards, so that ships sent forth from them in apparent cruising fitness may prove most truly to be so.

Of but slightly less importance is the superintendence of the work done by the shipbuilding yards on machinery for new ships. No one who has not studied the intricacies and difficulties connected with the installation of the power plant of a modern battleship can conceive of the numberless interferences while in course of construction which must be reconciled by personal superintendence, and always with a view to the efficient operation of the plant. Such a superintendence is of untold value, and makes all the difference between an ever available and ready vessel for service and one which is constantly seeking a navy yard for changes or repairs. Such work is necessarily arduous, and the limit of personal endurance must be considered in providing proper numbers.

After this, and clearly connected with it, comes the necessity of having inspectors at the producing mills for closely watching the output of material and attending to the physical and chemical tests of the same, in order that condemnation may not take place at the machine shops after transportation, and attendant long delays be experienced.

The following figures will give an idea of the great improvement in the manufacture of steel material for the engines and boilers of war vessels, brought about by the system of inspection now carried on, and aided by the desire of the American manufacturers to stand preeminent in this line of work, an ambition which frequently caused them to do work at a small profit or no profit at all, taking their reward in the advertisement gained and the prospect of future business.

The item of large engine forgings of steel, principally shafting, will illustrate the point in question, when we compare the steel specifications for the *Maine* and *Texas*, dated 1888 and 1889, respectively, with the requirements for the same class of material for battleships, monitors, torpedo-boat destroyers and torpedo

boats now under construction, appropriated for by the act of Congress approved May 4, 1898.

The specifications for machinery steel for the *Maine* and *Texas* required a tensile strength varying from 56,000 to 70,000 pounds per square inch, with an elongation of from 16 to 20 per cent. in 2 inches, both depending on where the test piece was taken; while the specifications for the new vessels, dated 1898, just ten years later, require for high-grade shaft forgings, nickel-steel, oil tempered and annealed, a tensile strength of at least 95,000 pounds per square inch, an elastic limit of 65,000 pounds per square inch, with an elongation of 21 per cent. in 2 inches. All the shafting for torpedo boats Nos. 24 to 35 was made of this material, while in the battleships, monitors and torpedo-boat destroyers the crank shafts alone were made of nickel-steel, simply annealed, with a tensile strength of 80,000 pounds per square inch, an elastic limit of 45,000 pounds per square inch, with an elongation of 26 per cent. in 2 inches, the remainder of the shafting for these vessels being of the higher-grade quality previously mentioned. The possibility of thus reducing machinery weight without sacrifice of endurance and strength is clearly obvious.

One of the most important duties clearly under this Bureau, and one which the personnel bill has made even more important, if possible, than heretofore, is that connected with the instruction in engineering branches of the cadets at the Naval Academy. This special instruction in the combined course should never be left to the control of other than engineers of great practical experience as well as high theoretical attainments, and I deem it a privilege to guard the character of the course by nominating officers of peculiar fitness for this work.

Lastly, the apportionment of efficient officers to the ships in the Navy as heads of the steam engineering department is clearly one of moment, and illustrates in the present state of the roster the necessity of putting into effect such regulations as will immediately bring to the front officers of the former line best fitted for conducting such work, and which will lead to eventually producing the line engineer of experience who will be able to succeed to the positions of still higher importance noted above. I

would ask that you take into consideration the vital importance of establishing alternation of deck and engine-room duty for the present watch officer of the line, in order that there may be no future shortcomings and no sad or disastrous deficiency in guarding these interests.

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After repeating his former recommendation that an Assistant Chief of Bureau be provided, Admiral Melville alludes to the subject of "Warrant Machinists" as follows:

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WARRANT MACHINISTS.

I feel it necessary to draw your attention to the necessity of governing the duties of this new grade of mechanics in such a way as will secure to the service their continued skillful assistance as direct operators and repairers of machinery. With the official elevation which comes with a warrant there is not unreasonable apprehension that these men will desire a severance from actual manual care of the machinery of our ships, and will expect to act merely as engineering supervisors below. This, of course, would be wholly inconsistent with the interests of the service, as at no previous time in naval history has there been a greater demand for the highest mechanical skill in the persons of those who have direct charge of marine motive power. Clear and definite regulations are needed on this point at the start, in order that no ambiguity may foster discontent with simple duty or lead to hopes of further official elevation. The engineer officer is and must be the line officer of the future; the warrant machinist must recognize the necessity of his expert mechanical work as well as the distinction he is given by the reason of his excellence in it.

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WORK IN THE DRAFTING ROOM.

The inspection of designs submitted for machinery being built for new vessels of the Navy is a work requiring the closest attention and is in every sense arduous. With the forty-eight vessels actually in hand at the various shipbuilding establish-

ments, the number of working drawings submitted is enormous, and it is to this feature of the drafting-room work that the Bureau desires to draw special attention in reference to a necessity for requesting increased force in clerical and drafting capacity.

I have included in my estimates for the coming fiscal year the item of salary for one chief draftsman at $2,250 per annum. Your favorable consideration is particularly requested for this item, as one which should not be omitted in the appropriation. The cost of this addition to the drafting-room force is most trifling compared with the resultant advantage of having a permanent expert head to the actual drafting force, who can work continuously under the experienced engineers in charge, and carry on without interruption the policy of the Bureau in design when by necessities of the service the officers have to be changed.

The experience drawn from numberless trials and reported necessities for change, for increasing efficiency of ships already commissioned, enables the Bureau to arrange plans for new ships with the greatest assurance of resulting excellence. This experience, however, does not extend itself to the drafting rooms of the shipbuilders, and constant changes in submitted designs are of necessity being made by the Bureau in order to preserve the very best conditions and to insure further efficiency. While carrying on this work of supervision and the attendant correspondence, there has been prepared also upon the drawing boards the following designs during the year:

Preliminary plans of machinery for battleships 13, 14 and 15, at a designed speed of 18½ knots.

Arrangement of machinery for armored cruisers 4, 5 and 6, with machinery plans for 22 knots.

Preliminary plans for 20-knot protected cruisers.

Plans and specifications of machinery for protected cruisers 14 to 19, drawings of which are attached to this report.

Machinery plans for ferry launch for Norfolk Navy Yard and Mare Island Navy Yard.

Minor plans for the *Chesapeake* auxiliary machinery.

Plans showing changes in machinery of various steam launches,

the object of which is to secure interchangeability of parts of machinery for same sizes of launches.

Plans for minor changes in machinery of the *Fern* and *Katahdin*.

Complete layout and arrangement for new boilers in the *Cincinnati*, the change being made from the old Scotch boilers to Babcock & Wilcox water-tube boilers. The same general layout will apply equally to the *Raleigh*.

Plans in preparation for new high-pressure cylinders for the engines of the *Cincinnati*, made necessary by the higher pressures to be carried in the new boilers. This will also apply equally to the *Raleigh*.

Plans showing arrangement of water-tube boilers on the *Alert*.

Designs for new boilers for the tug *Triton* being built at the navy yard, Norfolk.

Changes in valve gears for the *Atlanta* and *Hartford*.

Drawings for new propeller shafts for the *Marietta*, *Wilmington* and *Helena*.

In addition to the above, designs have been made for the layout of new steam-engineering shops at the navy yards, New York, Mare Island and Port Royal, and much detail regarding the interior arrangement of these gone into.

Attention has been given to the collecting of, and tabulating for future use, valuable data from the designs and weight sheets, and also from indicator diagrams, study being constantly given to improvements in general design based upon valuable and exact information.

The questions of best cylinder ratios for multiple-expansion engines, economical arrangements for using superheated steam, practical limit for true economy in forced draft, reduction of cost of horsepower of auxiliary machinery by improved design, efficient feed-water heating by exhaust steam, and the still further improvement in the screw propeller, tending to bring it nearer the point of highest efficiency, are among those most important in the work of this branch of the Bureau.

There is much work connected with the drafting room and the clerical work of the Bureau which can not be kept up to a de-

sirable state of completion, especially in connection with tabulating data. These, if properly arranged, are of utmost value to the Bureau and to the Department, and an increase both in draftsmen and in the clerical force of the Bureau being highly desirable, your attention to the matter and favorable recommendations to Congress are requested.

INSPECTION OF MATERIAL.

The importance of this work as alluded to above in this report can scarcely be overrated, and its continuance by engineering experts should be a matter unhesitatingly followed. The following detailed statement regarding the work under this head during the year is a valuable record, and illustrates more graphically than anything else could the broad field covered by the many builders in placing orders for material and the extensive nature of the inspection duty. While the statement shows the total amount of material accepted, the fact must not be lost sight of that a very large percentage of material is necessarily rejected at the works, and that percentage should be added to fully represent the actual labor involved in this particular duty.

This Bureau has now permanent inspection headquarters, in charge of commissioned officers, at the following places:

1. Homestead Steel Works, Munhall, Pa., one officer, with four civilian assistant inspectors and one copyist, who do all work at Pittsburg, Pa., and suburbs, Ellwood, Pa., Greenville, Pa., Johnstown, Pa., Washington, Pa., Latrobe, Pa., Cleveland, Ohio, Shelby, Ohio, Youngstown, Ohio, and Buffalo, N. Y.

2. The Midvale Steel Company's works, Nicetown, Philadelphia, Pa., one officer, with two civilian assistant inspectors, who do the work at Philadelphia, Pa., and suburbs, Conshohocken, Pa., Coatesville, Pa., Parkesburg, Pa., Phœnixville, Pa., and Pottstown, Pa.

3. The Bethlehem Steel Company, South Bethlehem, Pa., one officer, with two civilian assistant inspectors and one copyist, who do the work at Bethlehem, Pa., and High Bridge, N. J.

The laboratory at this place, built by the Bethlehem Steel Company for the use of this Bureau, is used exclusively for the

work of the Navy Department, and is provided with chemicals and apparatus by the Department. One assistant inspector, aided by a messenger boy, does here all the chemical work coming under its cognizance.

4. The American Steel Casting Company, Thurlow, Pa., one officer, with one civilian assistant inspector, does all the work at Thurlow, Pa., Chester, Pa., and Wilmington, Del.

5. The Pennsylvania Steel Company, Steelton, Pa., one officer, with one civilian assistant inspector, does the work at Steelton, Pa., Harrisburg, Pa., Danville, Pa., Reading, Pa., Middletown, Pa., Athens, Pa., Syracuse, N. Y., and Elmira, N. Y.

6. The Continental Iron Works, Brooklyn, N. Y., one officer does the work in Greater New York, Hoboken, N. J., Newark, N. J., Harrison, N. J., and Whitestone, Long Island.

7. The Pope Tube Company, Hartford, Conn., one officer, with one civilian assistant inspector, does the work at Hartford, Conn., Waterbury, Conn., Bridgeport, Conn., Ansonia, Conn., Torrington, Conn., New London, Conn., Providence, R. I., Boston, Mass., Taunton, Mass., Canton Junction, Mass., and New Bedford, Mass.

8. Masonic Temple, Chicago, Ill., one officer inspects at Chicago, Ill., Milwaukee, Wis., and St. Paul, Minn.

The officers and civilian assistants, under the cognizance of this Bureau, tested, inspected and shipped for the Bureau of Yards and Docks, 4,679,296 pounds of structural material, plate, angles, shapes and rivets, also the structural work of putting together this material; for the Bureau of Equipment, 503,233 pounds of structural material, anchors and their fittings; for the Bureau of Construction and Repair, 1,978 pounds of castings; for the Fish Commission, 102,864 pounds of boiler material, and for work coming under its own cognizance, 5,299,800 pounds of steel forgings, steel castings, steel plates, boiler bracing, steel and iron rivets, steel and iron bolts and nuts, steel and iron boiler tubes, steel and iron steam and water pipe, condenser tubes, brass and copper pipe and sheets, finished corrugated furnaces, steam drums for tubular boilers, and other finished articles in brass, copper, steel and iron, the grand total successfully passing inspection being 10,587,175 pounds.

The work was distributed among the following companies in cities and towns reaching from Boston, Mass., to St. Paul, Minn.:

American Steel Casting Company, 230,560 pounds of steel castings, of which 135,549 pounds was for the Bureau of Equipment, the remaining material being used in the construction of the machinery of the *Dahlgren*, *Craven*, *Illinois*, *Wilmington*, *Stringham*, *Tingey*, *Maine*, *Ohio*, *Wyoming*, *Hopkins*, *Hull* and *Alabama*.

The Auburn Bolt and Nut Company, 25,427 pounds of seamless drawn tubes for the *Ericsson*.

Atha and Illingworth Company, 119,643 pounds of steel castings, blooms, bars and forgings for the *Dahlgren*, *Craven*, *Blakely*, *De Long*, *Lawrence*, *Macdonough*, *Shubrick*, *Stockton*, *Thornton*, *Connecticut*, *Bagley*, *Bailey*, *Biddle*, *Dale* and *Decatur*, as well as for the New York yard.

American Tube Works, 258,262 pounds of condenser tubes, brass and copper pipe for the *Stringham*, *Yorktown*, *Florida*, *Dale*, *Decatur*, *Blakely* and *De Long;* also for repairs to vessels, naval supply fund, and for general use at the navy yards, New York and Mare Island.

Allison Manufacturing Company, 296,019 pounds charcoal-iron boiler tubes for the *Puritan* and for the New York Navy Yard.

American Iron and Tube Company, 77,232 pounds iron pipe for naval-supply fund, navy yard, New York.

Bethlehem Steel Company, 236,120 pounds nickel-steel forgings, of which 693 pounds was for the Bureau of Construction and Repair, the remainder being used in the construction of the machinery of the *Stringham*, *Foote*, *Rodgers*, *Dahlgren*, *Craven*, *Bailey*, *Goldsborough*, *Blakely*, *De Long*, *Shubrick*, *Stockton*, *Thornton*, *Paul Jones*, *Perry*, *Preble*, *Maine*, *Dale* and *Decatur*, and for repairs to the *Newark* and *Wheeling*, and for the New York Navy Yard.

Benedict and Burnham Manufacturing Company, 150,977 pounds condenser tubes, brass and copper pipe for the *Bailey*, *Nicholson*, *O'Brien* and *Wilkes*, and for repairs to the *Indiana* and *Iowa*, and for the naval-supply fund, navy yard, New York.

Bridgeport Brass Company, 95,849 pounds condenser tubes,

brass and copper pipe for *Tingey*, *Paul Jones*, *Preble*, *Wisconsin* and *Wyoming*, and for the naval-supply fund at the navy yard, New York.

Carbon Steel Company, 514,432 pounds steel boiler plate, of which 3,990 pounds was for the Bureau of Yards and Docks, the remainder being used in the construction of the boilers of the *Bailey*, *Nicholson*, *O'Brien*, *Shubrick*. *Stockton*, *Thornton*, *Hull*, *Paul Jones*, *Hopkins*, *Dale*, *Decatur*, *Lawrence*, *Blakely*, *De Long*, *Bainbridge*, *Barry*, *Chauncey*, *Connecticut*, *Macdonough* and *Florida*, and for repairs to the *Alert*, and for navy yard, Boston, Mass.

Continental Iron Works, welded steam and water drums for water-tube boilers and corrugated furnaces, the weight of which has been once taken note of at the steel works.

Coe Brass Manufacturing Company, 77,473 pounds condenser tubes, brass and copper pipe for the *Worden*, *Truxtun* and *Whipple*, and for repairs to the *Indiana* and *Columbia*.

Central Iron and Steel Company, 97,630 pounds steel plates for the Bureau of Yards and Docks.

Cambria Steel Company, 54,100 pounds steel plate and shapes for the Bureau of Yards and Docks.

Homestead Steel Works, 1,015,730 pounds steel plate, angles and shapes, of which 1,004,300 pounds was for the Bureau of Yards and Docks, the remainder being for the *Illinois* and repairs to the *Monadnock*.

Dauphin Bridge Company, 213,589 pounds structural material for the Bureau of Yards and Docks.

Elmira Bridge Company, 312,511 pounds structural material for the Bureau of Yards and Docks.

Franklin Machine Company, 7,283 pounds of iron castings for the *Shubrick*.

Holmes, Booth & Hayden, 52,896 pounds brass and copper pipe for repairs to the *Monadnock*, and for the navy yard, Norfolk, Va.

Hussey, C. G., & Co., 4,251 pounds Muntz metal plates for *Dale* and *Decatur*.

Lower Union Mills, 370,426 pounds steel plates, angles and shapes, of which 161,763 pounds was for the Bureau of Yards

and Docks and 195,553 pounds for the Bureau of Equipment, the remainder being for repairs to the *Indiana*.

Latrobe Steel Works, 2,181 pounds steel-pipe flanges for *Dahlgren*, *Craven* and *Stringham*.

Lukens Iron and Steel Company, 443,294 pounds steel plate, of which 70,830 pounds was for the Fish Commission, 260,239 pounds for the Bureau of Yards and Docks, and the remainder for repairs to the *Pontiac*.

Midvale Steel Company, 139,364 pounds steel forgings, of which 91,030 pounds was for the Bureau of Equipment, 1,285 pounds for the Bureau of Construction and Repair, the remainder being nickel-steel forgings, to be used in the construction of the machinery of the *Hopkins*, *Hull*, *Nicholson*, *O'Brien*, *Bainbridge* and *Barry*, and for repairs to the *Cushing*.

National Tube Works, 586,504 pounds lap-welded and seamless-drawn iron and steel boiler tubes and pipes, of which 16,864 pounds was for the Fish Commission, the remainder being used in the construction of the boilers of the *Stringham*, *Dahlgren*, *Craven*, *Goldsborough*, *Dale*, *Decatur*, *Perry*, *Paul Jones*, *Preble*, *Shubrick*, *Stockton*, *Truxtun*, *Whipple*, *Worden*, *Thornton*, *Blakely*, *De Long*, *Tingey*, *Bainbridge*, *Barry*, *Chauncey*, *Hopkins* and *Hull*, and for repairs to the *Vesuvius*, *Massachusetts*, *Oregon*, *Texas*, *Katahdin* and *Iris* and for the Norfolk and New-York navy yards.

New Bedford Copper Company, 6,732 pounds of Muntz metal sheets for the *Truxtun*, *Whipple* and *Worden*.

The Penn Steel Casting and Machine Company, 44,713 pounds steel castings, of which 1,563 pounds was for the Bureau of Equipment, the remainder being used in the construction of machinery of the *Stringham*, *Kearsarge*, *Kentucky*, *Goldsborough*, *Tingey*, *Bailey*, *Florida*, *Nicholson*, *O'Brien* and *Connecticut*.

Pacific Rolling Mills, 1,277 pounds steel plates for the *Wisconsin*.

Parkersburg Iron Company, 508,412 pounds skelp for boiler tubes for the *Puritan* and other vessels.

Pope Tube Company, 288,915 pounds seamless-drawn steel

tubes for the *Shubrick*, *Stockton*, *Tingey*, *Hopkins*, *Hull*, *Thornton*, *Dale*, *Decatur*, *Chauncey*, *Bainbridge* and *Barry*.

Park Brothers & Company, 57,110 pounds steel boiler plates for the Bureau of Equipment.

Phœnix Iron Company, 587,948 pounds steel angles and shapes, of which 453,398 pounds was for the Bureau of Yards and Docks, 570 pounds for the Fish Commission, and the remainder used in the construction of the machinery of the *Maine*, *Hopkins*, *Hull*, *Lawrence*, *Macdonough* and *Tingey*.

Pittsburg Bridge Company, 218,640 pounds structural steel material for the Bureau of Yards and Docks.

Pencoyd Iron Company, 4,113 pounds steel angles and shapes, of which 1,777 pounds was for the Bureau of Yards and Docks, the remainder being for the *Nicholson* and *O'Brien*.

Randolph & Clowes, 93,074 pounds condenser tubes, brass and copper pipe for repairs to the *Indiana* and *Massachusetts* and for the naval-supply fund at the New York and Mare Island navy yards.

Revere Copper Company, 21,111 pounds Muntz metal and copper sheets for the *Decatur*, *Stockton*, *Shubrick*, *Dale*, *Thornton*, *Missouri* and *Arkansas*.

Shelby Steel Tube Company, 1,188,068 pounds seamless-drawn steel tubes for the *Dupont*, *Porter*, *Foote*, *Rodgers*, *McKee*, *Preble*, *O'Brien*, *Nicholson*, *Perry*, *Blakely*, *Stockton*, *Shubrick*, *Thornton*, *Stewart*, *Paul Jones*, *Wilkes* and *De Long*, and for repairs to the *Winslow*, *Nashville*, *Iowa*, *Brooklyn*, *Bennington*, *Minneapolis*, *Texas*, *Ericsson*, *Alert*, *Scorpion* and *Bancroft*, and for the New York yard.

Sizer Steam Forge Company, 2,400 pounds nickel-steel forgings for tugboat No. 7, the *Pawtucket*.

Sternberg & Son, J. H., 29,489 pounds rivets, bolts and nuts, of which 14,600 pounds was for the Fish Commission, the remainder being used in the *O'Brien*, *Nicholson*, *Shubrick*, *Stockton*, *Thornton*, *Dahlgren*, *Craven*, *Dale*, *Decatur*, *Bagley*, *Barney*, *Biddle* and *Tingey*, and for the naval-supply fund at the New York and Boston navy yards.

Severance, Samuel, 7,995 pounds rivets for the Bureau of Yards and Docks.

Tyler Tube Company, 89,300 pounds charcoal-iron boiler tubes for the *Illinois*.

Taylor Iron and Steel Company, 1,921 pounds steel castings for the *Shubrick*, *Stockton* and *Thornton*.

Taylor, Lewis & Co., 6,054 pounds steel plates for the *Stringham*.

Taunton Copper Company, 3,946 pounds copper sheets for the *Connecticut*, *Barney* and *Biddle*.

Union Bridge Company, 796,790 pounds structural material for the Bureau of Yards and Docks.

Upper Union Mills, 1,105,755 pounds steel plates, angles and shapes, of which 1,103,797 pounds was for the Bureau of Yards and Docks and the remainder for the *Illinois*.

Worth Brothers Company, 132,713 pounds steel boiler plates for the *Paul Jones*, *Perry* and *Preble*, and for repairs to the *Indiana* and *Terror*.

The Alan Wood Company, American Steam Gauge Company, Deoxidized Bronze and White Metal Company, Pratt & Cady, and The Star Brass Company furnished finished articles amounting to 1,815 pounds in weight.

The Bureau finds that there has been great improvement during the year in the manufacture of high-grade engine forgings. The two companies who have taken contracts for these forgings, which are of nickel-steel, oil tempered and annealed, or of nickel-steel annealed, have been very successful in meeting all the requirements of the specifications, but in consequence of the rush of trades orders have not turned out as rapidly as was expected for the new battleships, monitors, torpedo boats and torpedo-boat destroyers authorized by the act of Congress approved May 4, 1898, but from this time on their production will be more rapid, all the difficulties in their manufacture having been practically overcome.

The manufacturers of seamless-drawn steel pipe have increased the size and power of their machinery so that steam and water pipe up to 7 inches in diameter can now be made in long lengths

and 9-inch pipe in lengths up to 9 feet. The flanges for these pipes are either solid, welded on, rolled on, or riveted on; but there is a fair prospect that the manufacturers will soon be able to turn out these sizes with flanges made by upsetting the end of the pipe, spreading these upset ends, and then forming them into flanges, all of which work will be done at a single heat. This can now be successfully done in cases of the smaller sizes, and the results are highly satisfactory in both appearance and strength.

There has been some discussion as to what is meant by "solid drawn" tubes. With this Bureau this term only includes tubes drawn through dies from the solid ingot, and does not include lap-welded sections drawn down to smaller-sized tubes. The latter may present an excellent surface, but there is always a possibility of a weld being started in the process of drawing, and yet of such a slight nature as only to show as a defect after being put in service.

ELECTRICALLY-DRIVEN AUXILIARIES.

For some time past—in fact, ever since the successful use of electric motors for general power purposes on shore—the Bureau has been carefully investigating their adaptability to the driving of the numerous auxiliary engines on board ship, and, in view of the conclusion that the electric drive of the auxiliaries would not, under existing conditions, be so satisfactory and economical, on the whole, as the steam drive, believes it would be of interest to state the reasons for this conclusion.

This is the more appropriate because in some quarters the fact that electric motors are extensively used on shore has led to the belief that they would be equally successful on board ship. The Bureau has planned to use electric motors exclusively in its new plant at the Brooklyn Navy Yard, and it will be readily appreciated, therefore, that their non-use on board ship is for very good reasons.

The advantages claimed for electric motors over small steam engines on board ship may be classed as greater ease of operation, avoidance of heat, which accompanies the use of steam pipes in living places, and much greater economy. Against these, how-

ever, are to be put the much greater weight of the necessary electric outfit, the greater delicacy of the type of electric motors ordinarily used, the lack of ready adaptability to the various conditions of service, a general denial of the claims for economy as ordinarily presented, and the increase in the amount of space required below the protective deck for the installation of the necessary dynamo rooms, this space being necessarily taken from coal bunkers.

On board ship, where excess of weight is so carefully guarded against, it would certainly be very unwise to adopt a change of motive power involving great increase in weight, unless the advantages gained are very material. It must always be remembered that, speaking generally, on board ship the use of an electric motor involves a total weight for the motive power at least three times that of the motor itself, because there is always the generator and its driving engine, besides the motors supplied by them; or, in other words, the electric drive of an auxiliary will weigh at least three times as much as the steam drive, assuming the motor to weigh no more than the engine it displaces, although usually it does weigh more. The answer which would be made to this is, of course, very familiar to anybody who has studied the problem, viz: that the auxiliaries are not all in use at one time, and that therefore the generator capacity required is considerably less than the total motor capacity. This is another case where a statement which may be true elsewhere is not true for the circumstances on board ship. Our naval machinery has to be designed so that in time of action everything can be ready for use, and, as a matter of fact, a very little study of the question will show that it not only may but almost certainly would happen that every auxiliary on the ship, except the capstan engine and some of the boat winches, would be used simultaneously. Therefore this statement with regard to the generator capacity does not hold on board ship.

Another statement to which very emphatic objection must be entered is in respect to the enormous gain in economy claimed for the electric drive of the auxiliaries, which is obtained by tak-

ing the highest figure for the efficiency of the generator and motor and also the most economical steam engine, and by comparing these results with the uneconomical form of steam cylinders which, for very good reasons, have until recently ordinarily been used with the steam-driven auxiliaries. If the electric generator was of relatively large size and the motors worked always at their most economical speed and load there might be some justification for this claim; but, as a matter of fact, the very circumstances under which the auxiliaries on board ship are worked require a very wide range of speed and power, and I believe that electric experts admit that electric motors as at present designed when run under these conditions are by no means economical, so that, without considering the economy of the engine driving the electric generator, the economy of motor-driven auxiliaries at speeds differing materially from the most economical would be widely different from those which are set forth by the advocates of their universal use on board ship. The natural result of the foregoing is that, with the widely varying speeds of the auxiliary machinery, there is required at the generator the development of an almost constant power which is very near the maximum, and which depends only upon the number of auxiliaries in use.

I wish to emphasize the point that the objection to using electric motors for driving the auxiliaries on board ship is not an objection to the use of electric motors per se, but to installing them in a location for which they are not adapted and where their good features can not be utilized. What has led to the wide use of electric motors on shore is not only the absence of heat, cleanliness and ease of installation and operation, but above all the simplicity of the transmission of power from a central station to a distance. Now the great majority of the auxiliaries on board ship are so near the boilers that less piping is involved in a direct steam drive than in an electric drive from dynamos necessarily at some distance from the boilers.

The ease of transmitting power to a distance over a wire, as compared with great lengths of steam piping, gives the electric drive a very attractive side, even for distances no greater

than the maximum ones on board ship, so that we should naturally expect to find electrically-driven capstans and steering engines. These two auxiliaries are not under this Bureau, but are the ones requiring long and objectionable steam pipes through the living spaces. Here, however, another point has been made by some who are very anxious to use motors elsewhere, viz: that for the service in these cases motors are not sufficiently reliable. Naturally a system involving four parts, each liable to break down, is more delicate than one involving but two of these parts. With a steam drive there are the boilers and the steam engine driving the auxiliaries. In the electric drive we have the boilers, the steam engines, and also the electric generators and motors. It is merely a detail whether the steam engines operate the auxiliaries directly or whether a smaller number of them, having a greater power in each engine, operate electric dynamos. Personally I should think, however, that if motors are considered sufficiently reliable to drive feed pumps and air pumps on shipboard, for which they are not well adapted, they would be reliable for these other two cases noted, which they fit so well otherwise. The absurdity of an electric drive of auxiliary machinery on board ship situated closer to the main engines than the engines driving the dynamos becomes all the more apparent when contrasted with the steam drive for auxiliaries situated in the very extreme ends of the ship.

The fact is that within what are ordinarily called the "machinery compartments of the ship" the leading of the necessary steam and exhaust pipes for auxiliaries does not interfere with anybody's comfort nor does it raise the temperature unduly, and the distances are so short as to make the lead of piping very easy. Steam auxiliaries answer admirably the demands which come upon them at all speeds within their capacity, and the only possible objection which can be urged against them is that the simple forms usually employed for reliability are not so economical as the more elaborate ones which can be used elsewhere. They are far superior to electric motors on the score of adaptation to the service to be performed, and also far better for naval use on the score of weight. On the score of economy, we have shown

above that the claims ordinarily made for the electric drive are not tenable, except under special conditions, and it is further to be said for the steam-driven auxiliaries that at the times when economy is of the greatest importance when making long sea trips only a small part of the total auxiliary capacity is used, so that even if the saving by the use of electricity was what is claimed by the most enthusiastic electrical agents the aggregate amount of fuel saved would be comparatively insignificant and considerably less than the reduction in bunker capacity necessarily incident in a ship of a given size to the use of the electric drive.

It must also be noted that all the published statements of the superior economy of electrically-operated auxiliaries are based on steam auxiliaries where every steam cylinder was of the least economical kind, and where, for good reasons, well-known measures of economy had not been installed. An inspection of the Bureau's recent designs will show that by the use of compound engines as motors, feed heaters for the exhaust, the use of the exhaust steam from the auxiliaries in the receivers of the main engines, and other economical devices, the expenditure of steam in the auxiliaries is brought much below that of the old simple engines, and indeed below that of the electric drive except under very favorable conditions, while avoiding the increased complication and weight which necessarily accompany electrically-driven auxiliaries on board ship. I may be permitted to call attention in this connection to the fact that those designers abroad who have the most extended experience are working on this problem of the economy of auxiliaries along the same lines that the Bureau has been following. Although the statement is very often made that the electric drive of the auxiliaries is being rapidly adopted in all foreign navies, this is far from accurate. It is being tried on some ships in some navies, but is as yet entirely in the experimental stage. These experiments have been carried quite as far in our Navy as in any other. I think I may be pardoned for saying that those who are most insistent on the electric drive are not at all conversant with the conditions obtaining on board ship, while those of us who have spent a

lifetime in the care and design of naval machinery may fairly claim that we know something about what is needed. It is perfectly safe to say that when electric machinery can be used more advantageouly than steam for driving ships' auxiliaries the change will be made very promptly. Knowing, as they do, that as at present designed electric machinery, however good elsewhere, is not yet adapted to driving the auxiliaries on board ship, the Bureau chiefs would be incompetent if they yielded to the craze for new things and made a change which would result in increase of weight and complication, lack of economy, dissatisfaction and decreased efficiency of the fleet.

In this connection I desire to submit the following facts and calculations:

On the battleship *Alabama* the space required for electric motors, where used, is approximately the same as that required for steam engines to do the same work. The space required for the wiring, etc., is less than that necessary for steam piping, had that been used. The space required for the generating sets is 10,140 cubic feet. The capacity of these generating sets is 256 kilowatts total. If all the auxiliary machinery on board this ship were operated by electricity, and if the space required for the electric generators were increased in the ratio of the increase of necessary capacity in the generating room, the space that would be required in the generating rooms would be 50,700 cubic feet for a capacity of 1,280 kilowatts. Consequent upon the extension of the use of electricity would be an increase in the total weight of the machinery equal to from 150 to 250 tons as a minimum. This loss in weight is as much as the gain following the use of water-tube boilers. The increased space occupied by the larger generating rooms would accommodate 900 tons of coal, or 3,600 horsepower could be added to the power of the propelling engines, giving the ship in the first instance 45 per cent. greater coal endurance, or in the second instance 1.5 knots increase in speed.

The foregoing figures as to the space required for the installation of larger generating sets are undoubtedly excessive, but they are based upon the present practice. It seems to me that at the

best we would at present have to pay an excessive price for electricity.

This weight and space required would be very much less if the size of the electric generating units could be largely increased without loss to the efficiency of the ship. At present, however, it is necessary for the efficient operation of the turret-turning machinery and of the ammunition hoists that small units be used, for these purposes at least. Probably when the designers of electrical machinery for naval use give as much attention to the development of designs to suit naval conditions as they have already done in commercial work this necessity will be overcome.

I consider that the turbine engine has a distinct field as an electric generating engine, especially on shipboard. When the design of naval electrical machinery is sufficiently advanced to justify the use of large units the advantages of turbine engines will cause a great saving in weight and space.

The operation of electrical machinery is purely mechanical. That this may be done efficiently requires good mechanical ability at the generating engines. Electric difficulties and casualties are almost always questions of mechanical engineering. I know that it would conduce to the efficiency of the service, to the feasibility of a more extended use of electricity, and to an increase in the life of electrical apparatus if the electric generating plant were placed in charge of this Bureau. I therefore recommend that this change be authorized. I desire to call your attention to the fact that it is almost the universal commercial practice to place electric generating plants in the charge of mechanical engineers.

* * *

EXPERIMENTS AND TESTS.

Under this heading the report gives:

A test of a Babcock & Wilcox boiler for the *Alert.*

A test of the machinery of the *Pennsylvania.*

A test of the machinery of the *Alexander McDougal.*

A test of a Niclausse boiler at Cramps.

A test of the evaporating plant of the *Iris.*

Of the above the first two tests were separately written up for the JOURNAL, and have been published in former numbers of this volume. The last two tests we here reprint as valuable data.

* * *

TESTS OF A NICLAUSSE BOILER AT THE WORKS OF WILLIAM CRAMP & SONS, PHILADELPHIA, PA.

A series of tests was made May 2 to 6, 1899, by a board composed of Lieutenants H. Hall, W. W. White and E. Theiss, United States Navy, on a Niclausse water-tubular boiler installed as a part of the dry-dock power plant at the establishment of the William Cramp & Sons Ship and Engine Building Works, Philadelphia, to determine the economy of the boiler at several different rates of coal consumption, and the economical effect, if any, following the operation of a heater located in the escaping gases, and by which means, when in use, the air entering the ash pit was considerably raised in temperature.

The boiler tested was of a stationary form and setting, with the following principal dimensions:

Diameter of drum, inches	36
Length of drum, inches	72
Number of malleable iron headers	7
Number of steam generating tubes connected to each header	18
Total number of steam generating tubes	126
Effective length of steam generating tubes, feet	$8\frac{1}{6}$
Diameter of steam generating tubes, inches	$3\frac{5}{16}$
Number of inner circulating tubes	126
Diameter of inner circulating tubes, inches	2
Thickness (sheet iron) of inner circulating tubes, B.W.G.	20
Tube heating surface, square feet	1,081.5
Heating surface in headers, square feet	10.5
Total heating surface, square feet	1,092
Width of grate, feet and inches	5– 5
Length of grate, feet and inches	3–$10\frac{1}{2}$
Grate surface, square feet	21
Air space in grate, per cent	50
Ratio of H.S. to G.S.	52 to 1
Boiler setting, 8 feet 4 inches wide by 10 feet long by 14 feet 7 inches high.	
Diameter of smoke pipe, feet	4
Height of smoke pipe, feet	60

The original grate was shortened from 5 feet 2 inches to 3 feet 10½ inches, reducing the grate surface from 28 to 21 square feet. The ratio of H.S. to G.S. was by this change increased from 39 : 1 to 52 : 1.

A belt-driven fan blower had been installed in a shed adjoining the boiler house for forcing the draft. This fan discharged the air through a duct of 17 inches diameter, and it was admitted to the ash pit through an opening controlled by a damper valve; also through a separate opening controlled by a damper valve and through interstices between the fire-brick lining of the furnace at one side, near the front, above the grate. It was claimed that the introduction of air above the grate led to more complete combustion, but no noticeable change was produced by the opening or closing of the air-admission valve.

The air duct was so arranged that the air on its way to the ash pit could be made to pass along the tubes of a heater, located at the bottom of the flue at back of boiler, or so that it could be passed directly to the ash pit, through a by-pass duct, sliding blank flanges being arranged for this purpose.

The air heater consisted of a nest of vertical tubes expanded at both ends into horizontal tube plates. The gases of combustion passed through the tubes, and the air to be heated passed among them, entering at one side of the boiler and leaving at the other.

The following are the principal dimensions of the forced-draft apparatus and the air heater:

Fan, 3 feet 7 inches diameter by 19¾ inches wide; 5 vanes.	
Outlet, inches	21½ by 21½
Pulley, diameter, inches	10
Engine, inches	8 by 8
Flywheel pulley, diameter, inches	36
Heater:	
Number of tubes	102
Length of tubes, feet and inches	3– 4½
Diameter of tubes, inches	3
Thickness of tubes, B.W.G.	No. 14
Area through tubes, square feet	4.96
Area between tubes, square feet	3.14
Air duct, diameter, inches	17
Area of inlet above grate, square foot	0.36

The instruments used were not calibrated by the board, but were of standard make, and no doubt exists as to their substantial accuracy. The pyrometer used for recording temperatures in the flue was of the metallic dial variety; its readings are supplemented by a record of metals melted.

The cooling tank used during the first three tests for obtaining the quality of steam by the Carpenter separating calorimeter was too small to give reliable results; for the last two tests a more capacious tank was secured, but the results as to quality of steam did not differ materially from those of the previous tests; the steam was in all cases practically dry. A portable Orsat apparatus was used for making the fuel gas analyses, which analyses were made by the chemist of the firm at his laboratory. The samples were taken with the greatest possible care.

The steam pressure was kept as nearly constant as possible by the manipulation of a stop valve allowing of the escape of steam to the atmosphere. During a part of the tests the boiler experimented on was used for furnishing steam to the dry-dock pumping machinery, but the regulation of pressure proceeded just as smoothly and in the same manner as when steam was permitted to escape into the air.

The feed pump had been mounted near the boiler, with all pipe connections in plain sight, and the water level was kept as nearly as possible at the uniform height of 2 inches in the gage glass.

The firing was done by the same experienced man during all the tests. This man fired at frequent intervals and little at a time, keeping the fires as thin as possible. The flue gas analysis shows at all times a large percentage of free oxygen, and a small percentage, relatively, of carbonic dioxide, showing that much surplus air passed through the grate. It is noticeable, however, that the analysis of flue gas taken off with fires purposely carried heavy (see analysis of gases drawn off at 2.55 P. M., May 5, test No. 4) also shows a large excess of air. Some of this apparent excess is accounted for by leaks in the brick setting, though they are totally inadequate to account for more than a small percentage. The relief fireman did not have the experience of the regu-

lar hand, and his taking hold was always signalized by a decided jump in the temperature of uptake gases. Also toward the end of each test, when the firing became less careful, a similar jump is to be recorded. In fact, the boiler, as is to be expected from the straightway course of the gases, is extremely sensitive to variations in firing with consequent variations in the uptake temperatures.

Five tests were undertaken on five consecutive days, May 2 to 6, 1899:

The first test was undertaken using cold ash-pit draft, burning as nearly as possible 30 pounds of coal per square foot of grate surface per hour. The table shows that 27.45 pounds were burned.

The second test was run under as nearly as possible the same conditions as the first, the only difference being that the air was passed through the heater on its way to the furnace. It was difficult to regulate the blower so as to obtain the desired uniform rate of combustion. The day preceding had been warm and murky, and the day of the second trial opened in the same way. In the course of the day, however, the weather cleared and a fresh breeze sprang up, increasing in strength, so that the blower, started at 500 revolutions, had to be gradually slowed to 330.

The coal burned per hour per square foot of grate during this test was 27.52 pounds, practically the same as on the day preceding. The evaporation per pound of coal under actual conditions rose from 7.72 to 7.84 for a difference in temperature of the air entering the ash pit of (189.1—106.4)=82.72 for the two days, with a corresponding difference in the temperature of uptake gases at base of chimney of (457—341.5)=115.5 degrees.

The third test was undertaken to determine the performance of the boiler under natural draft, burning as much coal as possible. The weather conditions were similar to those obtaining on the previous day, and a brisk fire was easily maintained, so that the consumption was not much below what it would have been with ash-pit draft, being 24.62 pounds per square foot of grate surface per hour.

The fourth test was intended to demonstrate the performance of the boiler under easy firing, natural draft, and 14.74 pounds of coal were burned per square foot of grate per hour.

The fifth test was undertaken to demonstrate the performance of the boiler under what may be assumed to be maximum forced-draft conditions on naval vessels other than torpedo boats and destroyers. The consumption reached the figure of 46.76 pounds per square foot of grate per hour. The blower delivered into the closed ash pit, and the air heater was in use. During this test, in the course of which the air pressure in the furnace averaged slightly above atmospheric pressure, the leaks in the brick setting manifested themselves by the escape of smoke, which hung over the top of boiler and made reading of the steam calorimeter difficult. One of the furnace doors became badly warped during this test, not having been a good fit at the start, and some loss occurred due to the loss of flame from this furnace mouth. The leakage was imperfectly stopped by wrapping the door with asbestos sheet.

The coal used in all tests was Clearfield (Pa.) coal, Atlantic brand. A quantity of this coal had been stored close to hand in a shed, and the coal used in tests Nos. 1–4 was taken from this supply. For test No. 5 the coal was carted from another part of the yard. The following proximate analyses of the coal and ash were made by the firm's chemist, Mr. Jesse Jones:

COAL USED IN TEST OF NICLAUSSE BOILER.

Number.	Run of—	Moisture.	Volatile.	Fixed.	Ash.	Color of ash.
3,381	May 2	0.45	18.85	73.20	7.50	Grayish-white.
3,390	May 3	.55	18.45	74.65	6.35	Grayish-white.
3,416	May 4	.80	16.05	73.00	10.15	Gray.
3,421	May 5	.95	17.55	75.10	6.40	Gray.
3,432	May 6	.80	18.75	73.50	6.95	Gray.

ASH FROM ABOVE.

Number.	Run of—	Moisture.	Volatile.	Fixed.	Ash.
3,382	May 2	0.10	2.45	12.95	84.50
3,391	May 3	.05	2.85	15.60	81.50
3,417	May 4	.10	2.40	21.05	76.45
3,422	May 5	.05	2.90	16.25	80.80
3,433	May 6	.10	3.10	10.50	86.30

SUMMARY OF TESTS OF A NICLAUSSE BOILER AT WILLIAM CRAMP & SONS' SHIP-YARD, MAY 2-6, 1899.

	1	2	3	4	5
Number of trial	1	2	3	4	5
Date of trial, 1899	May 2.	May 3.	May 4.	May 5.	May 6.
Duration of trial.....hours	6	6	10	10	6
Kind of start	Flying.	Flying.	Standard.	Standard.	Flying.
AVERAGE PRESSURES.					
Barometer.....inches	29.95	29.99	30.16	30.15	30.24
Steam pressure in boiler by gage.....lbs.	121.9	124.7	122.3	122.8	124.9
Draft in blower duct to ash pit..ins. water	.26	.19	*	*	.71
Draft in ash pit.....do.	.32	.22	*	*	.86
Draft in furnace.....do.	.08	.09	.22	.16	.08
Draft in flue behind boiler.....do.	.11	.14	.26	.18	.13
Draft at base of smoke pipe.....do.	.37	.43	.40	.34	.50
Revolutions of blower.....per minute	343	423	...	...	781.
AVERAGE TEMPERATURES.					
External air.....degrees Fahrenheit	84.6	70.7	62	69.4	69
Fire room.....do.	98.2	80.4	79.8	85	96.6
Feed water entering boiler.....do.	64.8	64.9	64.3	65.2	65.2
Air before entering heater.....do.	...	83.7	...	...	86.2
Air entering ash pit.....do.	106.4	189.1	...	...	219.9
Flue gases before entering heater....do.	...	525	464	389	794
Flue gases after passing heater.....do.	457	341.5	...	...	592.5
AVERAGE FLUE GAS ANALYSIS.					
Carbon dioxide.....per cent.	6.18	5.07	4.95	6.74	7.10
Oxygen.....do.	11.58	13.73	13.63	11.62	9.60
Carbonic oxide.....do.	.94	.62	.77	.53	.90
Nitrogen.....do.	81.30	80.58	80.65	81.11	82.40
FUEL.					
Kind of coal	†	†	†	†	†
Wood used in lighting fire.....pounds	...	...	300	300	...
Coal as fired‡.....do.	3,459	3,468	5,170	3,095	5,891.5
Moisture in coal.....per cent.	3	2.69	3.03	3.38	1.25
Dry coal consumed.....pounds	3,355.2	3,374.7	5,013	2,990.4	5,818
Ash and refuse.....do.	236	244	335	233	340
Combustible consumed.....do.	3,119.2	3,130.7	4,678	2,767.4	5,478
Refuse in dry coal.....per cent.	7.03	7.23	6.68	7.46	5.84
RATES OF COMBUSTION PER HOUR.					
Coal consumed.....pounds	576.5	578	517	309.5	981.9
Dry coal consumed.....do.	559.2	562.5	501.3	299	969.7
Combustible consumed.....do.	519.9	521.8	467.8	276.7	913
Coal consumed per square foot of grate surface.....do.	27.45	27.52	24.62	14.74	46.76
Dry coal consumed per square foot of grate surface.....do.	26.63	26.79	23.87	14.24	46.18
Combustible consumed per square foot of grate surface.....do.	24.76	24.85	22.28	13.18	43.48
Coal consumed per square foot of water-heating surface.....do.	.528	.529	.473	.283	.899

* Natural draft.
† Clearfield Bituminous-Atlantic brand.
‡ Including equivalent of wood used in lighting fires.

SUMMARY OF TESTS OF A NICLAUSSE BOILER—Continued.

Number of trial	1	2	3	4	5
Dry coal consumed per square foot of water-heating surface.....pounds..	.512	.515	.459	.274	.888
Combustible consumed per square foot of water-heating surface.....do..	.476	.478	.428	.253	.836
QUALITY OF STEAM.					
Quality of steam (dry steam = unity)....	.999	.999	.999	.998	.993
WATER.					
Total fed to boiler and apparently evaporated.....pounds..	26,688	27.156	38,166	24,952	42,390
Actually evaporated, corrected for quality of steam.....do..	26,661	27,129	38,128	24,902	42,093
Factor of evaporation.....	1.197	1.198	1.197	1.197	1.198
Equivalent water evaporated into dry steam from and at 212 degrees....lbs..	31,913	32,500	45,639	29,808	50,427
WATER PER HOUR.					
Evaporated, corrected for quality of steam .....pounds..	4,443.6	4,521.5	3,812.8	2,490.2	7,015.5
Equivalent evaporation from and at 212 degrees.....do..	5,318.8	5,416.5	4,563.9	2,980.8	8,404.5
Equivalent evaporation from and at 212 degrees, per square foot of grate surface.....do..	253.3	257.9	217.3	141.9	400.2
Equivalent evaporation from and at 212 degrees per square foot of water-heating surface.....do..	4.87	4.96	4.18	2.73	7.70
ECONOMIC RESULTS.					
Water apparently evaporated per pound of coal (including moisture) under actual conditions.....pounds..	7.72	7.84	7.38	8.06	7.20
Apparent equivalent evaporation from and at 212 degrees per pound of coal (including moisture).....do..	9.24	9.38	8.84	9.65	8.62
Equivalent evaporation (dry steam) from and at 212 degrees per pound of dry coal.....do..	9.51	9.63	9.10	9.97	8.67
Equivalent evaporation (dry steam) from and at 212 degrees per pound of combustible.....do..	10.23	10.38	9.76	10.77	9.21
Potential evaporation, or evaporation had all the heat obtained from fuel been utilized in converting the water in boiler into dry saturated steam from average temperature of feed water and under average boiler pressure per pound of dry coal.....do..	7.95	8.04	7.61	8.33	7.25
Same, per pound of combustible.....do..	8.55	8.67	8.15	9	7.70
Equivalent potential evaporation from and at 212 degrees per pound of dry coal.....do..	9.52	9.63	9.11	9.97	8.68
Same, per pound of combustible.....do..	10.24	10.38	9.76	10.78	9.22

CONCLUSIONS.

Of the mechanical details of the boiler little need be said, as they are sufficiently well known. The construction is such that tubes can be withdrawn and replaced with ease and rapidity, and the board witnessed this operation. It is of interest to record that for the purpose of cleaning the tubes of soot all were withdrawn and replaced during the nights following tests Nos. 1 and 2.

The boiler experimented on was designed for the moderate firing common in stationary practice, and while not differing in principles of construction and design of mechanical details from the marine type the evaporating tubes were $3\frac{5}{16}$ inches in diameter; so that while the ratio of H.S. to G.S. was high, 52:1, the gases were not as completely broken up as is the case with Niclausse boilers designed for marine use. In the marine type of boilers designed for battleships and cruisers the evaporating tubes are either all of $3\frac{1}{4}$ inches diameter or consist of a combination of $3\frac{1}{4}$ and $1\frac{9}{16}$-inch evaporating tubes, the lower rows being of the larger diameter. In the Niclausse torpedo-boat type of boiler all evaporating tubes are of the smaller diameter, $1\frac{9}{16}$ inches.

With the above in mind the performance of the boiler must be regarded as only fair for lower rates of combustion (tests 1, 2, 3 and 4) and as good for the higher rate, test 5.

At the conclusion of the tests the boiler was carefully examined, inside and out, being still hot and under about 40 pounds pressure, and no defects, injuries or leaks were discoverable beyond the warped furnace door above referred to.

On May 1, 1899, an experiment was made to determine the time required for getting up steam, of which the following is a record:

Started fires at 12.40 P. M. with wood and some oily waste. Used a few shovelfuls of fire from another boiler. Height of water in gage glass, $2\frac{5}{8}$ inches.

Steam formed at 1.01; height of water in gage glass, $9\frac{5}{8}$ inches.

Time.	Pressure.	Time.	Pressure.
1·04½	10	1·17½	60
1·08	15	1·18	70
1·14	20 *	1·19	80
1·14½	25	1·19½	90
1·15	30	1·20	100
1·16	40	1·20⅔	110
1·17	50	1·21	121 †

* Started blower. † Safety valve blows.

The time, while good, was not the best possible, as too much water had been pumped into the boiler at the start.

TEST OF THE EVAPORATING PLANT OF THE *IRIS*.

The Bureau is well pleased with the efficiency of this distilling ship, and believes such a type of vessel to be a most essential addition to any squadron. Large tank vessels, while able to carry a large quantity of fresh water, must for the replenishment of their stock rely upon shore streams, which may not be readily available. On the contrary, a distilling-ship supply is the ocean itself, and the water distilled therefrom free from the impurities, which in even the best of natural waters have scale-forming properties.

Several tests of the plant of the *Iris* were made before the vessel left the United States, but a better idea of the average output is obtained from the observations made and recorded during the voyage to Manila, when a continuous demand was made for fresh water by the accompanying ships.

The *Iris* left New York on the 14th of October, 1898, bound for Manila. The first stop was made at Bahia, Brazil, and there the ship delivered approximately 1,320 tons of fresh water to the other ships. Some of this water (about 400 tons) had been brought from New York. The remainder was distilled on board. On the trip from Bahia to Sandy Point, Chile, the evaporating plant was in operation only long enough to supply the drinking tanks and make about 20 tons of fresh water for make-up feed for the ship itself. On November 27, on arrival at Sandy Point, the plant was put in full operation and all tanks and double bot-

toms were filled. At Sandy Point the ship delivered 1,090 tons of fresh water to other ships. At Callao, Peru, after slight repairs to boilers had been made, the plant was again put in operation, and before leaving Callao the ship delivered 290 tons of fresh water to other ships, making in all 2,680 tons since leaving the United States, of which 2,280 tons had been made on board.

While at Sandy Point the plant was in operation for ten consecutive days and the actual quantity of water known. This, then, may be taken as a fair trial of performance. It was known that the output was approximately 1,100 tons, which gives a daily rate of 110 tons. This amount is just about half the rated capacity operating under the best conditions. A higher rate of economy, however, in coal cost of output was obtained by this moderate rate of distillation, and the data is of interest as being what may be considered a normal practical output when there is no desire to rush the plant at the expense of coal economy.

After the arrival of the *Iris* at Manila in the early part of May, 1899, a twenty-four-hour trial performance of the plant was held with the following results, which indicate the ability of the plant to produce readily about 200 tons of water per day.

Owing to insufficient steam supply from the main boiler in use at the time the maximum performance was not attained. One of the regular evaporator machinists being ill at the time, his place had to be taken by one comparatively inexperienced in taking care of the plant with all sets in operation. The weather was very warm, which naturally interfered with getting the best attendance from the men stationed on the evaporators.

RESULTS.

Duration of trial, hours	24
Grate area in use, square feet	70
Number of sets of evaporators in use (all)	4
Total quantity of water distilled, gallons	58,897
Total quantity of coal consumed, pounds	40,314
Unnecessary machinery in operation	Flushing pump.
Water distilled per pound of coal consumed, pounds	12.14
Water distilled per pound of coal consumed for distilling, pounds	12.88

Excepting two condensers, which gave signs of leaking, all the machinery of the distilling plant operated satisfactorily. The affected condensers were cut out, and the distillation continued without total stoppage of the plant, two condensers doing the duty of four.

DATA TAKEN DURING THE TRIAL.

Steam pressures.	Pounds by gage.	Steam pressures.	Pounds by gage.
Tubes of first effect	64.3	Tubes of first effect	58
Shell of first effect	39	Shell of first effect	40
Tubes of second effect	38	Tubes of second effect	38
Shell of second effect	16	Shell of second effect	22
Tubes of third effect	14.7	Tubes of third effect	20
Shell of third effect	1	Shell of third effect	1.5
Tubes of first effect	62.5	Tubes of first effect	63
Shell of first effect	41.5	Shell of first effect	40
Tubes of second effect	39.7	Tubes of second effect	37.5
Shell of second effect	19	Shell of second effect	17
Tubes of third effect	19	Tubes of third effect	17
Shell of third effect	1	Shell of third effect	1.3

CONCENTRATION OF WATER IN SHELLS.

.....	Set A.	Set B.	Set C.	Set D.
First effect	3½	3½	3⅜	3
Second effect	2⅝	3¼	3	3¼
Third effect	2¾	2⅞	3¼	3¼

TEMPERATURES.

	Degrees.
Sea water	85
Feed water	184
Discharge water	115
Distilled water	125
Evaporator room	121.8
Evaporator room, highest	125
Evaporator room, lowest	100

NOTE.—With the initial pressure of steam and object in view, it was found to be impracticable to carry lower pressures in the shells of the third effects on account of priming.

* * *

The remaining portion of the report contains details of expenditures at each navy yard and station, enumerating all the

PRINCIPAL DATA OF THE TRIAL TRIPS OF TORPEDO BOATS.

Name of vessel.	Type of vessel.	Displacement.	Type of engines. Vertical triple-expansion.	Cylinder diameters, in inches.			Stroke.	Number and type of boilers.	Total grate surface.	Total heating surface.	Trial speed.	Total, maximum I.H.P.	Total bunker capacity.	Total weight of machinery.	Present service.
				First H.P.	First I.P.	Second L.P.									
		tons.	*screws.*				*ins.*		*sq. ft.*	*sq. ft.*	*knots.*		*tons.*	*tons.*	
Davis.....	Torpedo boat No. 12.	132	2	11⅞	19	*d* { 22⅞ / 22⅞ }	15	2 Thornycroft.	88	4,763	{ 23.41, May 23, '99. }	*f* 1,750	40	52.04	At navy yard, Mare Island, Cal.
Farragut..	Torpedo boat No. 11.	273	2	20	29	*d* { 30 / 30 }	18	3 Thornycroft.	196	9,912	{ 30.13, Dec. 2, '98. }	*f* 5,600	76	108.31	Do.
Fox.....	Torpedo boat No. 13.	132	2	11⅞	19	*d* { 22⅞ / 22⅞ }	15	2 Thornycroft.	88	4,763	{ 22.05, Aug. 1, '99. }	*f* 1,750	40	51.92	Do.
Mackenzie..	Torpedo boat No. 17.	65	1	12	19½	*d* { 22 / 22 }	16	2 Thornycroft.	40	2,168	{ 20.11, May 25, '99. }	*f* 850	15.3	26.13	At Newport, R. I.
Rodgers....	Torpedo boat No. 4.	142	2	12	19½	*d* { 22 / 22 }	16	2 Mosher.	95	5,260	{ 24.49, Mar. 19, '99. }	2,295	44	50.82	At navy yard, New York.
Rowan.....	Torpedo boat No. 8.	182	2	14½	23	*d* { 25¾ / 25¾ }	18	3 Mosher.	142.5	7,890	{ 27.07, Apr. 22, '99. }	*f* 3,200	60	82.71	At naval station, Puget Sound, Wash.

d = 2 L.P. cylinders. *f* = designed.

vessels repaired at these places, and concluding with a most complete table of machinery data of all the vessels of the Navy, including details regarding vessels under construction.

While not reprinting all these details the table of principal trial data of torpedo boats and the remarks regarding the Cavite station are given in ending these extracts.

* * *

ENGINEERING PLANTS AT OUTLYING STATIONS.

While the Bureau is unable to foresee the governing policy most desirable in the future at these several newly-acquired stations, it can not but recommend that immediate steps be taken for establishing moderately large repair plants at each of these under this Bureau. I have included in my estimates a request for an appropriation of $25,000 each for the naval stations at Porto Rico and Honolulu, and have already taken steps to supply the naval station at Cavite with additional tools to those found there. The matter of further fitting up the station at Havana is under advisement, but no immediate steps are considered urgent owing to the proximity of that station to Key West. The present buildings at the Porto Rico station are substantial, and I consider it especially important that proper tools should be installed there.

In connection with the island of Guam, this Bureau has taken up the matter of supplying a distilling and refrigerating plant, but does not at present recommend any further installation of engineering material, owing to the uncertainties of the future.

A good general idea of the condition of the naval station at Cavite, and especially regarding the machine shops there, is obtained from the following extracts taken from the journal of Naval Cadet Daniel S. Mahony, written while on duty at that station.

The station is situated on a peninsula between Bakor Bay and Canacao Bay, the town of Cavite and Port San Felipe being also on the peninsula.

The buildings are old and in no way suited to a modern engineering establishment. The first one contains the machine shop and blacksmith shop, with boilers and engines to run the

same. Three heavy stone walls divide it into four parts, and used for different classes of work.

The boilers are old-fashioned affairs on the Lancashire plan, furnaces running their whole length. The furnaces have Galloway tubes. Steam pressure is around 20 pounds, and much more would be hard to get with such a leaky combination of pipes and valves as is on these boilers.

The machine-shop engine is a vertical, direct-acting, single, inverted affair, feed pump attached, worked by an eccentric and slide valve worked by a second crank. It is of interest solely as a relic.

The machinery in the shops, as shown in the sketch, is poorly placed. All of it is of the old heavy type and none of it much good. The centers of most of the lathes wobble. The shapers are very old-fashioned. There is only one gap lathe in the shop. There is no floor; the earth is rough and uneven and the roof leaks. On one side the roof is of tin, with large skylights; the other half of the shop has a solid roof and no windows on one side; so much of the work is done by candle light.

The blacksmith shop has modern forges, none of them very large. It has a blower run by belting from the machine-shop shafting. There is a large steam hammer, valuable as a curiosity, and a small one, somewhat better. There are no facilities for heavy forging. The shop has the usual tools and French anvils.

The boiler shop is merely a big shed. It has five forges, two shearing and punching machines. There is also an immense old punching machine, long past use. Power is furnished by a small horizontal engine, taking its steam from Cornish boilers, of which there are two.

The foundry contains three brass furnaces and three cupolas (all of which need rebuilding), a small engine, and a blower. There is no elevator behind the cupolas; all metal has to be carried up on the platform behind them. Their capacity is one and one-half tons. A fairly heavy casting can be made directly in front of the cupolas, where is a track on which a truss is mounted on wheels. Heavy ladles can be swung from this truss. It is hard to say whether the natives do green-sand molding or dry-sand molding, as they use green sand and build fires under the molds. Cutting a pattern in two they never heard of, but with trowels and slickers they make very intricate molds.

The pattern shop is primitive. It contains a bench with one vise, a few chisels, planes, hand saws, bow saws, and a lathe. The last consists of two parts—a table on which are two centers, one adjustable, and a wheel some six feet in diameter, much like

a cart wheel. A piece of wood to be turned is placed on the centers, and a rope belt put around it and around the big wheel, and while two men turn the latter a third holds the tool against the revolving wood. The natives much prefer, however, to sit upon a table, holding the piece of wood with their bare toes, and rounding it with a jack plane.

The marine ways are ordinary wooden affairs, a wooden bed sliding on rollers between wooden guides. The ways are moved by a large winch. The large ones are about 175 feet long and some 15 feet beam. The small ones are not over 100 feet long. The ways in the boat shed are an ordinary car track with a flat car on them. There is on the sea wall a large shears, good for about twenty-five tons, and a small crane for perhaps three or four tons. These are the only lifting facilities in the yard. Both are worked by hand.

An old-fashioned car track runs around the yard, and there are a few flat cars, but no locomotives.

The shipbuilding shop is the most modern thing in the yard. It has two Cornish boilers, and two large horizontal engines, modern. They have good governors and an expansion valve. A third eccentric on the shaft works a feed pump, which takes a brine mixture from a well. The machines in the shop are all rather old-fashioned, like everything else in the yard; still, if one can do with old-fashioned things, there should not be much trouble in getting along in a modern shop.

A large amount of work for the fleet has been done in the yard. In the foundry castings have been made for furnace fronts, bridge walls, pistons, pump chambers, etc., to say nothing of smaller articles. The blacksmiths have made heavy davits. In the boiler shop a boiler has had a new furnace fitted, been retubed, new stays put in—in fact, over half rebuilt. This work is worth bragging of, considering the means at hand.

Mr. Mahony followed the above description with a detailed account of the particular work he had had in charge connected with the repairs to tugs and refitting the machinery in the shops. In regard to the tugs he says:

Most of these boats have compound engines; four of French make, and one of English make, have the tandem type; the others have cross compound engines. There are only two arrangements of pumps and condensers. In one the condenser is athwartships; the engine columns serve for exhaust pipe, etc., and the

air, circulation, feed and bilge pumps are worked direct from the crossheads, on the cross compound type. The tandem engines so rigged have only circulation and air pumps worked this way. Their feed pump is worked by a wrist pin on their slide valve eccentrics, and they have an independent bilge pump. All these engines, though heavy, are very compact, and while saving room and cheap in first cost, are admirably planned for beheading the people working around them.

In the second type the condenser forms the back engine column; pumps for air, circulation, feed and bilge behind the condenser, worked by a rocking lever from a crosshead. These engines are good working, easy to handle, and not hard to repair. Some of them have the low-pressure crank leading the high—not a good plan.

In addition to what he had written in his notes, Mr. Mahony said, while at the Bureau, that it was necessary to spread canvas under the leaking roof whenever a casting was to be poured. He said that the old boiler and engine of the shop had been removed and replaced by a boiler from one of the sunken ships of May 1, and that one of the twin-screw engines of a Spanish torpedo boat had been used for the shop engine. He said the Filipino workmen did very good work, but that they had no ingenuity. After the Filipinos left, Chinese were used in their place with some advantage, the Chinese being slightly better workmen than the Filipinos. The American workmen had not arrived when he left, nor had any of the American tools sent out from this country. He said that one of the *Olympia's* boilers had been retubed, and that it was necessary to draw down the ends of the tubes, which were slightly too large. He said that considerable work had been done on each of the ships.

The Bureau purchased and forwarded to the Cavite station the following tools for immediate use, pending a fuller expansion of the shops at the station:

One 20-inch by 12-foot lathe.	One 2-inch bolt threader.
One 16-inch by 10-foot lathe.	One pressure blower.
One 14-inch by 5-foot lathe.	One 8-inch pipe-threading and cutting machine.
One 2 by 24-inch flat turret lathe.	One set of assorted taps, stocks and dies.
One 42-inch vertical boring mill.	One 16 by 10-inch double traveling head shaper.
One universal grinding machine.	One universal milling machine.

OBJECT LESSONS.

By A. B. Willits, U. S. Navy.

Marine engineers and modern shipbuilders will unquestionably concede that the most difficult feature to satisfactorily arrange in the machinery plant of a steamship is that of the piping, and particularly the portion of it which undergoes considerable change in length due to the temperature of the steam or hot water which it is required to convey.

With steam plants on shore ample space is primarily allotted in which to install piping of ideal simplicity and efficiency, and only culpable ignorance can occasion serious mistakes in the installation; but in the case of a steamship, and notably of a warship, the conditions are so entirely opposed to an easy solution of the problem as to make it necessary to give the closest study to the plans in order to avoid defective and even dangerous arrangements. Simple and direct leads are here seldom possible, as where the limit of machinery space is confined to the least number of cubic feet in which the apparatus can be effectively operated, and where overhead room is most meagre and rigidly blocked by a protective deck at about the water line, it is obvious that pipes connecting distant terminals must frequently be tortuous and the systems involved and complex.

The importance of properly providing for the expansion of the steam pipes in particular is the one detail in the piping problem which we wish to utilize in connection with our first object lesson in this paper. It would seem that the study of all the conditions bearing upon such an evidently essential attribute to an efficient plan would take precedence of many other engineering problems about which we read much; yet, strangely enough, this is not the case, and while the science of steam engineering is rapidly advancing on all other lines the disposition of the

the steam pipes in marine work appears to improve but slowly, and we hear continual complaints of really avoidable defects in both the lead and accessibility of these conductors, as well as in the actual manner of construction.

True it is that few real casualties force immediate remedial attention to the matter, but all seagoing engineers know that frequently more mental distress and manual toil are involved in the care and keeping of the pipe joints than in all the other work connected with the operation of the engines and dependencies. Also it is true that enormously greater stresses are constantly being put upon castings and joints by lack of provision to properly accommodate the expansion of these pipes than was ever calculated for in the design. This, up to the point of rupture, is seldom evidenced, save in leaky joints which *will* not keep tight despite the most skillful attention and frequent remaking. How many of us there are who have met with these troublesome joints! Sometimes it is a three-branch casting, fitting all three flanges of connecting pipes, when *cold*, perfectly, but when all the pipes are hot their expansion would make it absolutely impossible to remake the three joints were the casting then disconnected. Hence, under steam, great and abnormal expansive strains are brought on the connections, producing weeping and leaking until, perhaps, a crack in a nozzle points to the true cause of the trouble.

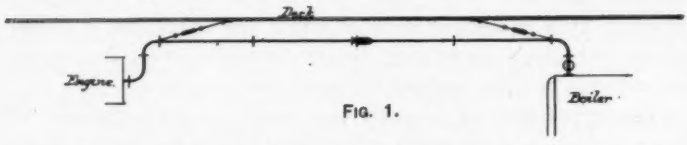

FIG. 1.

Of course the ideal steam lead is short and direct and has the two extremities anchored towards each other, while between the anchors are placed proper slip-joints which can accommodate all increase in lineal dimensions. (See Fig. 1.) But where this system cannot be followed we must not trust to bends and crooks to take up the expansion satisfactorily. Long loops provide, of course, a flexibility not found in short bends, but

even at the best this method brings side strains on the flanges and castings at elbows and bends which are forever tending to cockbill flanges and make joints difficult to keep tight, if they do not do more than that, by overstraining these parts. A good slip-joint in line of greatest expansion used in connection with "anchors" at such points as will compel accommodation by these slip-joints, are a necessary part of efficient piping, except where a trunnion joint, (such as adopted by Yarrow and described in object lessons in the August JOURNAL) can be adopted. Where to place the slip-joints, however, is as important as to have them, and an actual case in modern work is illustrated here (Fig. 2), which can well be studied as a bad example indeed.

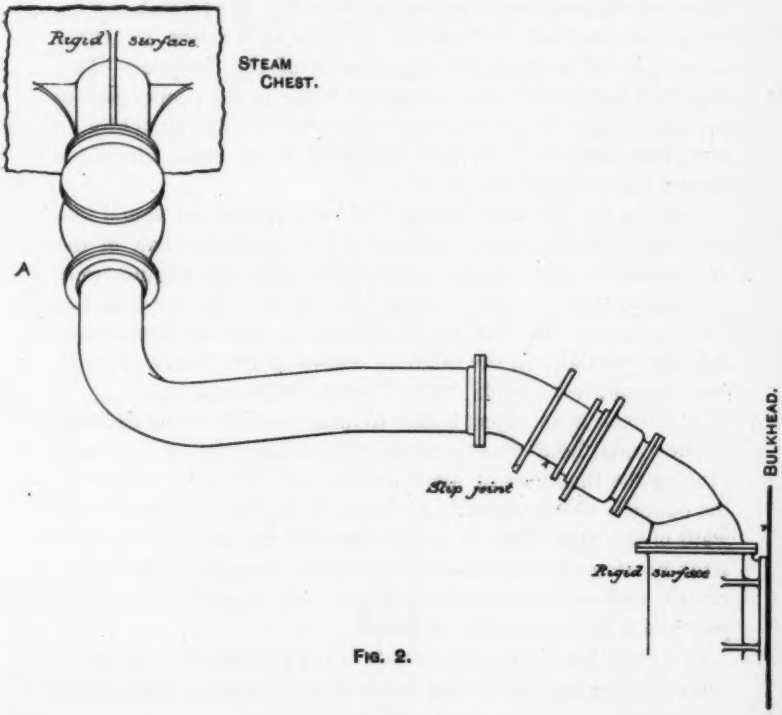

FIG. 2.

The figure is drawn in partial perspective, scarcely usual, yet most easily "read." Conceive a pressure of 160 pounds per square inch in this 15-inch pipe. Imagine then the elongation due to expansion by the heat, and observe the difficulty in compelling the slip-joint to take this up. Every tendency is for the pipe to spring that much *away* from the slip-joint, the steam pressure on the elbow (projected area of the pipe) assisting it. This pressure acting at the leverage it there has from elbow to the steam chest (about three feet) brings an enormous strain on the casting at the steam chest; a strain never intended or calculated for, so that as a result, a crack at the casting might well be expected, and that result was secured strictly according to Hoyle. To make matters worse, the slip-joint bolts had no shoulders to prevent *extraction* movement of the joint, being instead, provided with stiff springs to resist such action, but these springs failed to meet the expectation of the designer. This slip-joint is faulty in other ways, not being in the proper part of the pipe. This will be evident to anyone who will sketch in an imaginary outline of the pipe increased in all lineal directions by the approximate expansion.

Leaving the matter of piping to the thoughtful, we would like to illustrate a peculiar condition of the propeller shaft of the *Helena*, which was ruptured last August while the engines were running at 165 turns per minute. Examination by the Board of Survey showed the shaft to have broken in a helical form on one side and straight on the other as shown in the sketch (Fig. 3), and at about two feet six inches forward of the after strut.

The break is an object lesson to inspectors of hollow shafting, as the "axial hole" was found to be $\frac{17}{32}$ of an inch out of central, making the thickness of metal on one side $1\frac{29}{32}$ inches, while on the opposite side it was only $\frac{27}{32}$ inch. This great difference in the walls of the shaft taken in connection with the fact that the after strut bearing was considerably worn down, bringing a sort of eccentric motion on the shaft, caused a crack to start in the weak part and a speedy rupture to follow.

In noting the above one is reminded of the frequent reports of shaft failures, and attributing much of the trouble to corrosion at

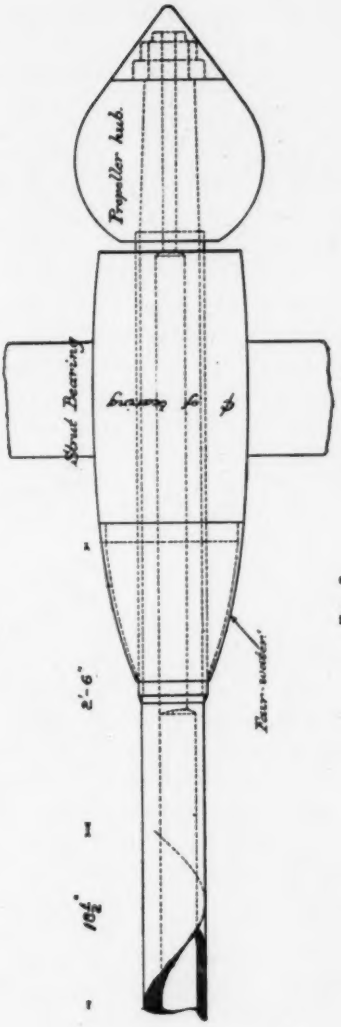

FIG. 3.

covered points. This experience, as far as weakening shafts by corrosion, has been a recent experience in the Navy, the shafts of the *Marietta* and *Wheeling* both having seriously corroded under the brass casing. Faulty fitting of casing was the primary cause, and it is important to further guard against such invisible deterioration by grooving the inner surface of casing and propeller hub also at the ends where the joints are to be made, and, after fitting, pump into the grooves some plastic waterproof material, having first drilled inlet and vent holes, and then plug up the holes. If it is thus made impossible for water to enter at the joints, it is not material if the casing does not absolutely hug the shaft "watertight" throughout. At the propeller end this is most important also, as here corrosion would more quickly reduce the shaft to point of rupture.

The "old, old story is told again" in the recent accident to the *Stringham*. It is only a revival of another object lesson, yet no number of warnings will securely guard the future from repetition of the carelessness. The following is from a report on the occurrence:

"The torpedo boat *Stringham* was taken out on the Delaware River for engine trials with fire under the two forward boilers only, having had a similar trial with the two after boilers on a previous date. After letting go of the tug at the mouth of the Christiana River we steamed down the Delaware River with steam varying from 100 to 200 pounds pressure per square inch, engines, pumps, blowers, etc., all running well, speed of main engines averaging from 100 to 300 per minute. Just before reaching Reedy Island we had the steam at 200 pounds for a second spurt at this pressure. We had just opened the throttle valve when a sharp jar and report was given out by the port engine, followed by a grinding noise. The engine was stopped at once. After careful external examination nothing could be discovered that would have caused the trouble, and we continued on with the starboard engine running and in a short time started up again with the port engine, which then seemed to run quietly. On arriving at our dock we at once opened up the steam chest common to the high-pressure and intermediate-pressure cylinders and found that a

small, solid wrench had been, through some one's carelessness, left in the valve chamber, and had worked into the port chamber and been caught by the valve. The result was a breaking out of the bridge between the ports and also breaking the valve. No examination has as yet been made of the valve-gear links, piston and connecting rods, but same will be done at once. The accident necessitated the making of a complete new pair of cylinders."

THE PROGRESS IN STEAM NAVIGATION.

By Sir William H. White.*

Steamship design, to be successful, must always be based on experiment and experience as well as on scientific principles and processes. It involves problems of endless variety and great complexity. The services to be performed by steamships differ in character, and demand the production of many distinct types of ships and propelling apparatus. In all these types, however, there is one common requirement—the attainment of a specified speed. And in all types there has been a continuous demand for higher speed.

Stated broadly, the task set before the naval architect in the design of any steamship is to fulfill certain conditions of speed in a ship which shall not merely carry fuel sufficient to traverse a specified distance at that speed, but which shall carry a specified load on a limited draught of water. Speed, load, power and fuel supply are all related, and the two last have to be determined in each case. In some instances, other limiting conditions are imposed affecting length, breadth, or depth. In all cases there are three separate efficiencies to be considered—those of the ship, as influenced by her form; of the propelling apparatus, including the generation of steam in the boilers and its utilization in the engines; and of the propellers. Besides these considerations the designer has to take account of the materials and structural arrangements which will best secure the association of lightness with strength in the hull of the vessel. He must select those types of engines and boilers best adapted for the service proposed. Here the choice must be influenced by the length of the voyage, as well as the exposure it may involve to storm and stress.

* Extracts from address before the Mechanical Science Section of the British Association.

Obviously the condition to be fulfilled in an oceangoing passenger steamer of the highest speed, and in a cross-channel steamer designed to make short runs at high speed in comparatively sheltered waters, must be radically different. And so must be the conditions in a swift seagoing cruiser of large size and great coal endurance, from those best adapted for a torpedo boat or destroyer. There is, in fact, no general rule applicable to all classes of steamships; each must be considered and dealt with independently, in the light of the latest experience and improvements. For merchant ships there is always the commercial consideration, Will it pay? For warships there is the corresponding inquiry, Will the cost be justified by the power and efficiency of the proposed ship?

CHARACTERISTICS OF PROGRESS IN STEAM NAVIGATION.

Looking at the results so far attained, it may be said that progress in steam navigation has been marked by the following characteristics: (1) Growth in dimensions and weights of ships, and large increase in engine power as speeds have been raised. (2) Improvements in marine engineering, accompanying increase of steam pressure. Economy of fuel and reduction in the weight of propelling apparatus in proportion to the power developed. (3) Improvements in the materials used in shipbuilding; better structural arrangements; relatively lighter hulls and larger carrying power. (4) Improvements in form, leading to diminished resistance and economy of power expended in propulsion. These general statements represent well-known facts, so familiar indeed that their full significance is often overlooked. It would be easy to multiply illustrations, but only a few representative cases will be taken.

TRANSATLANTIC PASSENGER STEAMERS.

Transatlantic service naturally comes first. It is a simple case, in that the distance to be covered has remained practically the same, and that for most of the swift passenger steamers cago-carrying capacity is not a very important factor in the design. In 1840 the Cunard steamer *Britannia*, built of wood, propelled by paddle wheels, maintained a sea speed of about 8½ knots. Her

steam pressure was 12 pounds per square inch. She was 207 feet long, about 2,000 tons in displacement, her engines developed about 750 horsepower, and her coal consumption was about 40 tons per day, nearly 5 pounds of coal per indicated horsepower per hour. She had a full spread of sail. In 1871 the White Star steamship *Oceanic*—first of that name—occupied a leading position. She was iron built, propelled by a screw, and maintained a sea speed of about 14½ knots. The steam pressure was 65 pounds per square inch, and the engines were on the compound principle. She was 420 feet long, about 7,200 tons in displacement, her engines developed 3,000 horsepower, and she burnt 65 tons of coal per day, or about two pounds per indicated horsepower per hour. She carried a considerable spread of sail. In 1889 the White Star steamer *Teutonic* appeared, propelled by twin screws, and practically with no sail power. She is steel built, and maintains a sea speed of about 20 knots. The steam pressure is 180 pounds per square inch, and the engines are on the triple-expansion principle. She is about 565 feet long, 16,000 tons in displacement, 17,000 horsepower indicated, with a coal consumption of about 300 tons a day, or from 1.6 to 1.7 pounds per indicated horsepower per hour. In 1894 the Cunard steamship *Campania* began her service, with triple-expansion engines, twin screws and no sail power. She is about 600 feet long, 20,000 tons displacement, develops about 28,000 horsepower at full speed of 22 knots, and burns about 500 tons of coal per day. The new *Oceanic*, of the White Star Line, is just beginning her work. She is of still larger dimensions, being 704 feet in length, and over 25,000 tons displacement. From the authoritative statements made, it appears that she is not intended to exceed 22 knots in speed, and that the increase in size is to be largely utilized in additional carrying power. The latest German steamers for the transatlantic service are also notable. A speed of 22½ knots has been maintained by the *Kaiser Wilhelm der Grosse*, which is 25 feet longer than the *Campania*. Two still larger steamers are now building. The *Deutschland* is 660 feet long, and 23,000 tons displacement; her engines are to be of 33,000 horsepower, and it is estimated that she will average 23 knots. The other ves-

sel is said to be 700 feet long, and her engines are to develop 36,000 horsepower, giving an estimated speed of 23½ knots. All these vessels have steel hulls and twin screws. It will be noted that to gain about three knots an hour nearly 50 per cent. will have been added to the displacement of the *Teutonic*, the engine power and coal consumption will be doubled, and the cost increased proportionally.

Sixty years of continuous effort and strenuous competition on this great "ocean ferry" may be summarized in the following statement: Speed has been increased from 8½ to 22½ knots; the time on the voyage has been reduced to about 38 per cent. of what it was in 1840. Ships have been more than trebled in length, about doubled in breadth, and increased tenfold in displacement. The engine power has been made forty times as great. The ratio of horsepower to the weight driven has been increased fourfold. The rate of coal consumption—measured per horsepower per hour—is now only about one-third what it was in 1840. To drive 2,000 tons weight across the Atlantic at a speed of 8½ knots per hour about 550 tons of coal were then burnt; now, to drive 20,000 tons across at 22 knots, about 3,000 tons of coal are burnt.

With the low pressure of steam and heavy, slow-moving paddle engines of 1840, each ton weight of machinery, boilers, etc., produced only about two horsepower. With modern twin-screw engines and high steam pressure, each ton weight of propelling apparatus produces from six horsepower to seven horsepower. Had the old rate of coal consumption continued, instead of 3,000 tons of coal, 9,000 tons would have been required for a voyage at 22 knots. Had the engines been proportionately as heavy as those in use sixty years ago they would have weighed about 14,000 tons. In other words, machinery, boilers and coals would have exceeded in weight the total weight of the *Campania* as she floats to-day. There could not be a more striking illustration than this of the close relation between improvements in marine engineering and the development of steam navigation at high speeds.

Equally true is it that this development could not have been accomplished but for the use of improved materials and structural

arrangements. Wood, as the principal material for the hulls of high-powered swift steamers, imposed limits upon dimensions, proportions and powers which would have been a bar to progress. The use of iron first, and since of steel, removed those limits. The percentage of the total displacement devoted to hull in a modern Atlantic liner of the largest size is not much, if at all, greater than was the corresponding percentage in the wood-built *Britannia* of 1840, of one-third the length and one-tenth the total weight. Nor must it be overlooked that with increase in dimensions have come considerable improvements in form favoring economy in propulsion. This is distinct from the economy resulting from increase in size, which Brunel appreciated thoroughly half a century ago when he designed the *Great Britain* and the *Great Eastern*.

The importance of a due relation between the lengths of the "entrance and run" of steamships and their intended maximum speeds, and the advantages of greater length and fineness of form as speeds are increased, were strongly insisted upon by Scott Russell and Froude. Naval architects, as a matter of course, now act upon the principle, so far as other conditions permit. For it must never be forgotten that economy of propulsion is only one of many desiderata which must be kept in view in steamship design. Structural weight and strength, seaworthiness and stability all claim attention, and may necessitate modifications in dimensions and form which do not favor the maximum economy of propulsion. Increase in length and weight have largely assisted the marvellous regularity of service now attained on the longest passages by swift steamships. Even the largest vessels at times have to yield to the forces of nature displayed in wind and sea. But these conditions are more rarely reached in the longer and heavier ships.

SWIFT PASSENGER STEAMERS FOR LONG VOYAGES.

Changes similar to those described for the transatlantic service have been in progress on all the great lines of ocean traffic. In many instances increase in size has been due not only to increase in speed, but to enlarged carrying power, and the ex-

tension of the lengths of voyages. No distance is now found too great for the successful working of steamships, and the sailing fleet is rapidly diminishing in importance. So far as long-distance steaming is concerned, the most potent factor has undoubtedly been the marvellous economy of fuel that has resulted from higher steam pressures and greater expansion. In all cases, however, advances have been made possible not merely by economy of fuel, but by improvements in form, structure and propelling apparatus, and by increased dimensions. This might be illustrated by many interesting facts drawn from the records of the great steamship companies which perform the services to the far East, Australia, South America, and the Pacific. I must be content, however, with the statement of a few facts regarding the development of the fleet of the Peninsular and Oriental Company. The paddle steamer *Willam Fawcett*, of 1829, was about 75 feet long, 200 tons displacement, of 60 nominal horsepower—probably about 120 indicated horsepower—and in favorable weather steamed at a speed of 8 knots. Her hull was of wood, and, like all the steamers of that date, she had considerable sail power.

In 1853 the *Himalaya*, iron-built screw steamer of this line, was described "of larger dimensions than any then afloat, and of extraordinary speed." She was about 340 feet long, over 4,000 tons load displacement, 2,000 indicated horsepower on trial, with an average sea speed of about 12 knots. The steam pressure was 14 pounds per square inch, and the daily coal consumption about 70 tons. This vessel was transferred to the Royal Navy, and did good service a troopship for forty years. In 1893 another *Himalaya* was added to the company's fleet. She was steel-built, nearly 470 feet long and 12,000 tons load displacement, with over 8,000 indicated horsepower and a capability to sustain 17 to 18 knots at sea on a daily consumption of about 140 tons of coal. The steam pressure is 160 pounds per square inch, and the engines are of the triple-expansion type. Comparing the two *Himalayas*, it will be seen that in forty years the length has been increased about 40 per cent., displacement trebled, horsepower quadrupled, and speed increased 50 per cent. The

proportion of horsepower to displacement has only been increased as three to four, enlarged dimensions having secured relative economy in propulsion. The rate of coal consumption has been probably reduced to about one-third of that in the earlier ship.

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CARGO AND PASSENGER STEAMERS.

Cargo steamers, no less than passenger steamers, have been affected by the improvement mentioned. Remarkable developments have occurred recently, not merely in the purely cargo carrier, but in the construction of vessels of large size and good speed, carrying very great weights of cargo and considerable numbers of passengers. The much decried "ocean tramp" of the present day exceeds in speed the passenger and mail steamer of fifty years ago. Within ten years vessels in which cargo carrying is the chief element of commercial success have been increased in length from 300 feet or 400 feet to 500 feet or 600 feet; in gross register tonnage from 5,000 to over 13,000 tons, and in speed from 10 or 12 knots to 15 or 16 knots. Vessels are now building for the Atlantic service which can carry 12,000 to 13,000 tons deadweight, in addition to passengers, while possessing a sea speed as high as that of the swiftest mail steamers afloat in 1880. Other vessels of large carrying power and good speed are running on much longer voyages, such as to the Cape and Australia.

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INCREASE IN SIZE AND SPEED OF WARSHIPS.

Turning from seagoing ships of the mercantile marine to warships, one finds equally notable facts in regard to increase in speed, associated with enlargement in dimensions and advance in propelling apparatus, materials of construction, structural arrangements and form. Up to 1860 a measured-mile speed of 12 to 13 knots was considered sufficient for battleships and the largest classes of cruisers. All these vessels possessed good sail power, and used it freely as an auxiliary to steam or as an alternative when cruising or making passages. When armored battleships were built—1859—the speeds on measured-mile trials were raised to 14 or 14½ knots, and so remained for about twenty

years. Since 1880 the speeds of battleships have been gradually increased, and in the latest types the measured-mile speed required is 19 knots. Up to 1870 the corresponding speeds in cruisers ranged from 15 to 16 knots. Ten years later the maximum speeds were 18 to 18½ knots in a few vessels. Since then trial speeds of 20 to 23 knots have been attained, or are contemplated. There is, of course, a radical distinction between these measured-mile performances of warships and the average sea speeds of merchant steamers above described. But for purposes of comparison between warships of different dates measured-mile trials may fairly be taken as the standard. For long-distance steaming the power developed would necessarily be much below that obtained for short periods, and with everything at its best. This is frankly recognized by all who are conversant with warship design, and fully allowed for in estimates of sea speeds.

On the other hand, it is possible to point to sea trials made with recent types where relatively high speeds have been maintained for long periods. For example, the battleship *Royal Sovereign* has maintained an average speed of 15 knots from Plymouth to Gibraltar, and the *Renown* has maintained an equal speed from Bermuda to Spithead. As instances of good steaming by cruisers, reference may be made to 60-hour trials with the *Terrible*, when she averaged over 20 knots, and to the run home from Gibraltar to the Nore by the *Diadem*, when she exceeded 19 knots. Vessels of the *Pelorus* class, of only 2,100 tons displacement, have made long runs at sea, averaging over 17 knots. Results such as these represent a substantial advance in speed of Her Majesty's ships in recent years.

Similar progress has been made in foreign warships built abroad as well as in this country. It is not proposed to give any facts for these vessels, or to compare them with results obtained by similar classes of ships in the Royal Navy. Apart from full knowledge of the conditions under which speed trials are made, a mere statement of speeds attained is of no service. One requires to be informed accurately respecting the duration of the trial, the manner in which engines and boilers are worked, the extent to which boilers are "forced," or the proportion of

heating surface to power indicated, the care taken to eliminate the influence of tide or current, the mode in which the observations of speed are made, and other details, before any fair or exact comparison is possible between ships. For present purposes, therefore, it is preferable to confine the illustrations of increase in speed in warships to results obtained under Admiralty conditions, and which are fairly comparable.

A great increase in size has accompanied this increase in speed, but it has resulted from other changes in modern types, as well as from the rise in speed. Modern battleships are of 13,000 to 15,000 tons, and modern cruisers of 10,000 to 14,000 tons, not merely because they are faster than their predecessors, but because they have greater powers of offense and defense, and possess greater coal endurance. Only a detailed analysis, which cannot now be attempted, could show what is the actual influence of these several changes upon size and cost, and how greatly the improvements made in marine engineering and shipbuilding have tended to keep down the growth in dimensions consequent on increase in load carried, speed attained, and distance traversed. It will be noted also that large as are the dimensions of many classes of modern warships, they are all smaller in length and displacement than the largest mercantile steamers above described. There is, no doubt, a popular belief that the contrary is true, and that warships exceed merchant ships in tonnage. This arises from the fact that merchant ships are ordinarily described, not by their displacement tonnage, but by their registered tonnage, which is far less than their displacement.

As a matter of fact, the largest battleships are only of about two-thirds the displacement of the largest passenger steamers, and from 200 feet to 300 feet shorter. The largest cruisers are from 100 feet to 200 feet shorter than the largest passenger steamers, and about 60 per cent. of their displacement. In breadth the warships exceed the largest merchant steamers by from 5 feet to 10 feet. This difference in form and proportions is the result of radical differences in the vertical distribution of the weights carried, and is essential to the proper stability of the

warships. Here we find an illustration of the general principle underlying all ship designing. In selecting the forms and proportions of a new ship considerations of economical propulsion can not stand alone. They must be associated with other considerations, such as stability, protection and maneuvering power, and in the final result economy of propulsion may have to be sacrificed to some extent in order to secure other essential qualities.

ADVANTAGES OF INCREASED DIMENSIONS.

Before passing on, it may be interesting to illustrate the gain in economy of propulsion resulting from increase in dimensions by means of the following table, which gives particulars of a number of typical cruisers, all of comparatively recent design:

.....	*No. 1.*	*No. 2.*	*No. 3.*	*No. 4.*	*No. 5.*
Length, feet.....	280	300	360	435	500
Breadth, feet.....	35	43	60	69	71
Mean draught, feet.....	13	16.50	23.75	24.50	26.25
Displacement, tons.....	1,800	3,400	7,400	11,000	14,200
I.H.P. for 20 knots.....	6,000	9,000	11,000	14,000	15,500
I.H.P. per ton of displacement..	3.3	2.65	1.48	1.27	1.09

The figures given are the results of actual trials, and embody, therefore, the efficiencies of propelling machinery, propellers and forms of the individual ships. Even so, they are instructive. Comparing the first and last, for example, it will be seen that while the displacement is increased nearly eightfold, the power for 20 knots is only increased about 2.6 times. If the same types of engines and boilers had been adopted in these two vessels (which was not the case, of course), the weights of propelling apparatus and coal for a given distance would have been proportional to the respective powers; that is to say, the larger vessel would have been equipped with only 2.6 times the weight carried by the smaller. On the other hand, roughly speaking, the disposable weights, after providing for hulls and fittings in these two vessels, might be considered to be proportional to their displacements. As a matter of fact, this assumption is distinctly in favor of the smaller ship. Adopting it, the larger ves-

sel would have about eight times the disposable weight of the smaller, while the demand for propelling apparatus and fuel would be only 2.6 times that of the smaller vessel. There would, therefore, be an enormous margin of carrying power in comparison with displacement in the larger vessel. This might be devoted, and, in fact, was devoted, partly to the attainment of a speed considerably exceeding 20 knots—which was a maximum for the smaller vessel—partly to increased coal endurance and partly to protection and armament.

Another interesting comparison may be made between vessels Nos. 4 and 5 in the preceding table, by tracing the growth in power necessary to drive the vessels at speeds ranging from 10 knots up to 22 knots.

It will be noted from the following table that up to the speed of 18 knots there is a fairly constant ratio between the powers required to drive the two ships. As the speeds are increased the larger ship gains, and at 22 knots the same power is required in both ships. The smaller vessel, as a matter of fact, was designed for a maximum speed of 20½ knots, and the larger for 22 knots. Unless other qualities had been sacrificed, neither space nor weight could have been found in the smaller vessel for machinery and coals corresponding to 22 knots. The figures are interesting, however, as illustrations of the principle that economy of propulsion is favored by increase in dimensions as speeds are raised.

.....	*No. 4.*	*No. 5.*
knots.	*horsepower.*	*horsepower.*
10	1,500	1,800
12	2,500	3,100
14	4,000	5,000
16	6,000	7,500
18	9,000	11,000
20	14,000	15,500
22	23,000	23,000

Going a step further, it may be assumed that in unsheathed cruisers of this class about 40 per cent. of the displacement will be required for the hull and fittings, so that the balance, or "dis-

posable weight," would be about 60 per cent., say, 6,600 tons for the smaller vessel and 8,500 tons for the larger, a gain of nearly 2,000 tons for the latter. If the speed of 22 knots were secured in both ships, with machinery and boilers of the same type, the larger ship would, therefore, have about 2,000 tons greater weight available for coals, armament, armor and equipment. These illustrations of well-known principles have been given simply for the assistance of those not familiar with the subject, and they need not be carried further. More general treatment of the subject, based on experimental and theoretical investigation, will be found in text books of naval architecture.

SWIFT TORPEDO VESSELS.

Torpedo flotillas are comparatively recent additions to war fleets. The first torpedo boat was built by Mr. Thornycroft for the Norwegian Navy in 1873; and the same gentleman built the first torpedo boat for the Royal Navy in 1877. The construction of the larger class known as "torpedo-boat destroyers," dates from 1893. These various classes furnish some of the most notable examples extant of the attainment of extraordinarily high speeds for short periods, and in smooth water, by vessels of small dimensions. Their qualities and performances, therefore, merit examination. Mr. Thornycroft may justly be considered the pioneer in this class of work. Greatly impressed by the combination of lightness and power embodied in railway locomotives, Mr. Thornycroft applied similar principles to the propulsion of small boats, and obtained remarkably high speeds. His work became more widely known when the results were published of a series of trials, conducted in 1872 by Sir Frederick Bramwell, on a small vessel named the *Miranda*. She was only 45 feet long, and weighed four tons, yet she exceeded 16 knots on trial. The Norwegian torpedo boat, built in 1873, was 57 feet long, $7\frac{1}{2}$ tons, and of 15 knots; the first English torpedo boat of 1877 was 81 feet long, 29 tons, and attained $18\frac{1}{2}$ knots.

Mr. Yarrow also undertook the construction of small, swift vessels at a very early date, and has greatly distinguished himself throughout the development of the torpedo flotilla. Messrs.

White, of Cowes, previously well known as builders of steamboats for use on board ships, extended their operations to the construction of torpedo boats. These three firms for a considerable time practically monopolized this special class of work in this country. Abroad they had able competitors in Normand in France, Schichau in Germany, and Herreshoff in the United States. Keen competition led to successive improvements, and rapid rise in speed.

During the last six years the demand for a fleet of about one hundred destroyers, to be built in the shortest possible time, involved the necessity for increasing the sources of supply. At the invitation of the Admiralty a considerable number of the leading shipbuilding and engineering firms have undertaken, and successfully carried through, the construction of destroyers varying from 26 to 33 knots in speed, although the work was necessarily of a novel character, involving many difficulties. As the speeds of torpedo vessels have risen, so have their dimensions increased. Within the class, the law shown to hold good in larger vessels applies equally. In 1877 a first-class torpedo boat was 81 feet long, under 30 tons weight, developed 400 horsepower, and steamed 18½ knots. Ten years later the corresponding class of boat was 135 feet long, 125 tons weight, developed 1,500 horsepower, and steamed 23 knots. In 1897 it had grown to 150 feet in length, 140 to 150 tons, 2,000 horsepower, and 26 knots. Destroyers are not yet of seven years' standing, but they come under the rule. The first examples—1893—were 180 feet long, 240 tons, 4,000 horsepower and 26 to 27 knots. They were followed by 30-knot vessels, 200 feet to 210 feet long, 280 to 300 tons, 5,500 to 6,000 horsepower. Vessels now in construction are to attain 32 to 33 knots, their lengths being about 230 feet, displacements 360 to 380 tons, and engine power 8,000 to 10,000 horsepower.

Cost has gone up with size and power, and the limit of progress in this direction will probably be fixed by financial considerations, rather than by constructive difficulties, great as these are as speeds rise. It may be interesting to summarize the distinctive features of torpedo vessel design.

(1) The propelling apparatus is excessively light in proportion to the maximum power developed. Water-tube boilers are now universally adopted, and on speed trials they are "forced" to a considerable extent. High steam pressures are used. The engines are run at a high rate of revolution—often at 400 revolutions per minute. Great care is taken in every detail to economize weight. Speed trials at maximum power extend over only three hours. On such trials in a destroyer each ton weight of propelling apparatus produces about 45 indicated horsepower. Some idea of the relative lightness of the destroyer's machinery and boilers will be obtained when it is stated that in a large modern cruiser with water-tube boilers, high steam pressure and quick-running engines, the maximum power obtained on an eight hours' trial corresponds to about 12 indicated horsepower per ton of engines, boilers, etc. That is to say, the proportion of power to weight of propelling apparatus is from three and a half to four times as great in the destroyer as it is in the cruiser.

(2) A very large percentage of the total weight—or displacement—of a torpedo vessel is assigned to propelling apparatus. In a destroyer of 30 knots trial speed, nearly one-half the total weight is devoted to machinery, boilers, etc. In the swiftest cruisers of large size, the corresponding allocation of weight is less than 20 per cent. of the displacement, and in the largest and fastest mail steamers it is about 20 to 25 per cent.

(3) The torpedo vessel carries a relatively small load of fuel, equipment, etc. Taking a 30-knot destroyer, for example, the speed trials are made with a load not exceeding 12 to 14 per cent. of the displacement. In a swift cruiser the corresponding load would be from 40 to 45 per cent., or proportionately more than three times as great. What this difference means may be illustrated by two statements. If the load were trebled, and the vessel correspondingly increased in draught and weight, the speed attained with the same maximum power would be about three knots less. If, on the other hand, the vessel were designed to attain 30 knots on trial with the heavier load, her displacement would probably be increased about 70 to 80 per cent.

(4) The hull and fittings of the torpedo vessel are exceedingly

light in relation to the dimensions and engine power. For many parts of the structure steel of high tensile strength is used. Throughout the utmost care is taken to economize weight. In small vessels, for special service, many conditions can be accepted which would be inadmissible in larger sea going vessels. The result of all this care is the production of hull structures having ample general strength, but very little local strength; but notwithstanding all the accidents of navigation and collisions that have occurred in this class of vessel—and they have not been few—not one has yet foundered at sea.

These conditions are essential to the attainment of very high speeds for short periods. They resemble the conditions ruling the design of cross-channel steamers, so far as relative lightness of propelling apparatus, small load and light scantlings are concerned. The essential differences lie in the requirements for passenger accommodation as compared with the requirements for armament of the torpedo vessel. No one has yet proposed to extend the torpedo-vessel system to seagoing ships of large dimensions. Very similar conditions for the propelling apparatus have been accepted in a few cruisers of considerable dimensions, wherein high speeds for short periods were required. It is, however, unquestionable that in many ways, and particularly in regard to machinery design, the construction of torpedo vessels has greatly influenced that of larger ships.

One important consideration must not be overlooked. For short-distance steaming at high speeds economy in coal consumption is of little practical importance, and it is all-important to secure lightness of propelling apparatus in relation to power. For long-distance steaming, on the contrary, economy in coal consumption is of primary importance; and savings in weight of propelling apparatus, even of considerable amount, may be undesirable if they involve increased coal consumption. Differences of opinion prevail as to the real economy of fuel obtainable with boilers and engines such as are fitted to torpedo vessels. Claims are made for some vessels which represent remarkable economy. Only enlarged experience can settle these questions. Endurance is also an important quality in seagoing ships of

large size; not merely in structure, but in propelling apparatus. The extreme lightness essential in torpedo vessels obviously does not favor endurance, if high powers are frequently or continuously required. Still it cannot be denied that the results obtained in torpedo vessels show such a wide departure from those usual in seagoing ships as to suggest the possibility of some intermediate type of propelling apparatus applicable to large seagoing ships, and securing sufficient durability and economy of fuel in association with further savings of weight.

THE PARSONS TURBO-MOTOR.

The steam turbo-motor, introduced by Mr. Charles Parsons, with its very high rate of revolution, reduces the weights of machinery, shafting and propellers greatly below the weight required in the quickest-running engines of the reciprocating type. This reduction in the proportion of weight to power carries with it, of course, the possibility of higher speed in a vessel of given dimensions, and when large powers are employed the absolute gain is very great. An illustration of this has been given by Mr. Parsons in the *Turbinia*. That remarkable vessel is 100 feet long, and of 44½ tons displacement, but she has attained 33 to 34 knots in short runs. There are three shafts, each carrying three screw propellers, each shaft driven by a steam turbine making over 2,000 revolutions at full speed, when an aggregate of more than 2,000 horsepower is developed. A water-tube boiler of special design supplies steam of 175 pounds pressure, and is exceptionally light for the steam produced, being highly forced.

The whole weight of machinery and boilers is 22 tons; in other words, about 100 horsepower indicated is produced for each ton weight of propelling apparatus. This is rather more than twice the proportion of power to weight as compared with the lightest machinery and boilers fitted in torpedo boats and destroyers. It will be noted that in the *Turbinia*, as in the destroyers, about half the total weight is devoted to propelling apparatus, and in both instances the load carried is relatively small. The secret of the extraordinary speed is to be found in

the extreme lightness of propelling apparatus and small load. No doubt in the *Turbinia* lightness has been pushed further than it would be in vessels of larger size and greater power. In such vessels a lower rate of revolution would probably be accepted, additional motors would be fitted for maneuvering and going astern, boilers of relatively greater weight would be adopted, and other changes made. But after making ample allowance for all such increases in weight, it is unquestionable that considerable economies must be possible with rotary engines. Two other vessels of the destroyer type with turbo-motors—one for the Royal Navy—are now approaching completion. Their trials will be of great interest, as they will furnish a direct comparison with vessels of similar size and form, fitted with similar boilers and driven by reciprocating engines.

On the side of coal consumption Mr. Parsons claims at least equality with the best triple-expansion engines. Into the other advantages attending the use of rotary engines it is not necessary now to enter. Reference must be made, however, to one matter in which Mr. Parsons has done valuable and original work. In torpedo vessels of high speed the choice of the most efficient propellers has always been a matter of difficulty, and the solution of the problem has, in many instances, involved extensive experimental trials. By means of alterations in propellers alone very large increases in speed have been effected; and, even now, there are difficulties to be faced. When Mr. Parsons adopted the extraordinary speed of revolution just named for the *Turbinia* he went far beyond all experience and precedent, and had to face unknown conditions. He has found the solution, after much patient and original investigation, in the use of multiple screws of small diameter. His results in this direction are of general interest to all who have to deal with screw propulsion. Such radical changes in propelling machinery as are involved in the adoption of turbo-motors must necessarily be subjected to thorough test before they will be widely adopted. The experiment which the Admiralty are making is not on a small scale as regards power. Although it is made in a destroyer, about 10,000 horsepower will probably be developed, and a cor-

respondingly high speed attained. It may well happen that from this experiment very far-reaching effects may follow. Mr. Parsons himself has prepared many designs illustrating various applications of the system to seagoing, cross-channel and special service vessels. Where shallowness of draught is unavoidable, the small diameter of the screws possible with the quick-running turbines is clearly an important matter.

COMPARISONS BETWEEN LARGE AND SMALL VESSELS.

It has been shown that the attainment of very high speeds by vessels of small size involves many conditions not applicable to large seagoing steamships. But it is equally true that in many ways the trials of small, swift vessels constitute model experiments, from which interesting information may be obtained as to what would be involved in driving ships of large size at speeds much exceeding any of which we have experience. When the progressive steam trials of such small vessels can be studied side by side with experiments made on models to determine their resistance to various speeds, then the fullest information is obtained, and the best guide to progress secured. This advantage, as has been said, we owe to William Froude. His contributions to the "Reports" of the British Association are classics in the literature of the resistance and propulsion of ships. In 1874 he practically exhausted the subject of frictional resistance, so far as it is known, and his presidential address in 1875 dealt fully and lucidly with the modern or stream-line theory of resistance. No doubt there would be advantage in extending Froude's experiments on frictional resistance to greater lengths and to ship-shaped forms. It is probable, also, that dynamometric determinations of the resistance experienced by ships of modern forms and considerable size, when towed at various speeds, would be of value if they could be conducted.

These extensions of what Froude accomplished are not easily carried out, and in this country the pressure of work on ship-building for the Royal Navy has for many years past taxed to the utmost limits the capacity of the Admiralty experimental establishment, so ably superintended by Mr. R. E. Froude, allow-

ing little scope for purely scientific investigations, and making it difficult to deal with the numerous experiments incidental to the designs of actual ships. Now that Holland, Russia, Italy and the United States have equipped experimental establishments, while Germany and France are taking steps in that direction, we may hope for extensions of purely scientific work and additions to our knowledge. In this direction, however, I am bound to say that much might be done if experimental establishments capable of dealing with questions of a general nature relating to resistance and propulsion were added to the equipment of some of our universities and colleges. Engineering laboratories have been multiplied, but there is as yet no example of a model experimental tank devoted to instruction and research.

It is impossible here to attempt any account of Froude's "scale of comparison" between ships and models at "corresponding speeds." But it may be of interest to give a few illustrations of the working of this method, in the form of a contrast between a destroyer of 300 tons, 212 feet long, capable of steaming 30 knots an hour, and a vessel of similar form enlarged to 765 feet in length and 14,100 tons. The ratio of dimensions is here about 3.61 : 1, the ratio of displacements is 47 : 1, and the ratio of corresponding speeds is 1.9:1. To 12 knots in the small vessel would correspond 22.8 knots in the large vessel, and the resistance experienced by the large vessel at 22.8 knots—neglecting a correction for friction—should be forty-seven times that of the small vessel at 12 knots. By experiment this resistance for the small vessel was found to be 1.8 tons. Hence, for the large vessel at 22.8 knots, the resistance should be 84.6 tons. This would correspond to an "effective horsepower" of over 13,000, or to about 26,000 indicated horsepower. The frictional correction would reduce this to about 25,000 horsepower, or about 1.8 horsepower per ton. Now, turning to the destroyer, it is found experimentally that at 22.8 knots she experiences a resistance of about eleven tons, corresponding to an effective horsepower of over 1,700 horsepower, and an indicated horsepower of about 3,000 horsepower; say, 10 horsepower per ton, or nearly five and a half times the power per ton required in

the larger vessel. This illustrates the economy of propulsion arising from increased dimensions.

Applying the same process to a speed of 30 knots in the large ship, the corresponding speed in the small ship is 15.8 knots. Her resistance at that speed is experimentally determined to be 3.5 tons, and the resistance of the large ship at 30 knots neglecting frictional correction, is about 165 tons. The effective horsepower of the large ship at 30 knots is, therefore, about 34,000 horsepower, corresponding to 68,000 horsepower indicated. Allowing for the frictional correction, this would drop to about 62,000 horsepower, or 4.4 horsepower per ton. For the destroyer at 30 knots the resistance is about 17½ tons; the effective horsepower is 3,600 horsepower, and the indicated horsepower about 6,000 horsepower, or 20 horsepower per ton—nearly five times as great as the corresponding power for the large ship. But while the destroyer under her trial conditions actually reaches 30 knots, it is certain that in the large ship neither weight nor space could be found for machinery and boilers of the power required for 30 knots, and of the types usually adopted in large cruisers, in association with an adequate supply of fuel. The explanation of the methods by which the high speed is reached in the destroyer has already been given. Her propelling apparatus is about one-fourth as heavy in relation to its maximum power, and her load is only about one-third as great in relation to the displacement, when compared with the corresponding features of the cruiser.

The earlier theories of resistance assumed that the resistance experienced by ships varied as the square of the speed. We now know that the frictional resistances of clean, painted surfaces of considerable length vary as the 1.83 power of the speed. This seems a small difference, but it is sensible in its effects, causing a reduction of 32 per cent. at 10 knots, nearly 40 per cent. at 20 knots, and 42 per cent. at 25 knots. On the other hand, it is now known that the laws of variation of the residual or wave-making resistance may depart very widely from the law of the square of the speed, and it may be interesting to trace for the typical destroyers how the resistance actually varies. Take

first, the total resistance. Up to 11 knots it varies nearly as the square of the speed; at 16 knots it has reached the cube; from 18 to 20 knots it varies as the 3.3 power. Then the index begins to diminish; at 22 knots it is 2.7; at 25 knots it has fallen to the square; and from there to 30 knots it varies practically as does the frictional resistance. The residual resistance varies as the square of the speed up to 11 knots; as the cube, at 12½ to 13 knots; as the fourth power, about 14½ knots; and at a higher rate than the fifth power at 18 knots. Then the index begins to fall, reaching the square at 24 knots, and falling still lower at higher speeds. It will be seen, therefore, that when this small vessel has been driven up to 24 or 25 knots by a large relative expenditure of power, further increments of speed are obtained with less proportionate additions to the power.

Passing from the destroyer to the cruiser of similar form but of 14,100 tons, and once more applying the scale of comparison, it will be seen that to 25 knots in the destroyer corresponds a speed of 47½ knots in the large vessel. In other words, the cruiser would not reach the condition where further increments of speed are obtained with comparatively moderate additions of power until she exceeded 47 knots, which is an impossible speed for such a vessel under existing conditions. The highest speeds that could be reached by the cruiser with propelling apparatus of the lightest type yet fitted in large seagoing ships would correspond to speeds in the destroyer, for which the resistance is varying as the highest power of the speed.

These are suggestive facts. Frictional resistance, as is well known, is a most important matter in all classes of ships and at all speeds. Even in the typical destroyer this is so. At 12 knots the friction, with clean, painted bottom, represents 80 per cent. of the total resistance; at 16 knots, 70 per cent.; at 20 knots, a little less than 50 per cent., and at 30 knots, 45 per cent. If the coefficient of friction were doubled, and the maximum power developed with equal efficiency, a loss of speed of fully 4 knots would result. In the cruiser of similar form the friction represents 90 per cent. at 12 knots, 85 per cent. at 16 knots, nearly 80 per cent. at 20 knots, and over 70 per cent. at 23 knots.

If the coefficient of friction were doubled at 23 knots, and the corresponding power developed with equal efficiency, the loss of speed would approximate to 4 knots. These illustrations only confirm general experience that clean bottoms are essential to economical propulsion and the maintenance of speed, and that frequent docking is necessary in vessels with bare iron or steel skins which foul in a comparatively short time.

POSSIBILITIES OF FURTHER INCREASE IN SPEED.

From the facts above mentioned it is obvious that the increase in speed which has been effected is the result of many improvements, and has been accompanied by large additions to size, engine power and cost. These facts do not discourage the inventor, who finds a favorite field of operation in schemes for attaining speeds of 50 to 60 knots at sea in vessels of moderate size. Sometimes the key to this remarkable advance is found in devices for reducing surface friction by the use of wonderful lubricants to be applied to the wetted surfaces of ships, or by interposing a layer of air between the skins of ships and the surrounding water, or other departures from ordinary practice. If these gentlemen would "condescend to figures" their estimates or guesses would be less sanguine. In many cases the proposals made would fail to produce any sensible reduction in resistance; in others it would increase resistance. Other proposals rest upon the idea that resistance may be largely reduced by adopting novel forms, departing widely from ordinary ship shapes. Very often small-scale experiments, made in an unscientific and inaccurate manner, are adduced as proofs of the advantages claimed. In other instances mere assertion is thought sufficient. Ordinarily no regard is had to other considerations, such as internal capacity, structural weight and strength, stability and seaworthiness. Most of these proposals do not merit serious consideration. Any which seem worth investigation can be dealt with simply and effectively by the method of model experiments. A striking example of this method will be found in the usual form of a parliamentary paper—No. 313, of 1873—containing a report made by Mr. William Froude to the Ad-

miralty. Those interested in the subject will find therein much matter of special interest in connection with the conditions attending abnormally high speeds. It must suffice now to say that ship-shaped forms are not likely to be superseded at present.

The most prolific inventions are those connected with supposed improvements in propellers. One constantly meets with schemes guaranteed by the proposers to give largely increased efficiency and corresponding additions to speed. Variations in the numbers and forms of screws or paddles, the use of jets of water or air expelled by special apparatus through suitable openings, the employment of explosives, imitations of the fins of fishes, and numberless other departures from established practice, are constantly being proposed. As a rule, the "inventors" have no intimate knowledge of the subject they treat, which is confessedly one of great difficulty. When experiments are adduced in support of proposals they are almost always found to be inconclusive and inaccurate. More or less mathematical demonstrations find favor with other inventors, but they are not more satisfactory than the experiments. An air of great precision commonly pervades the statements made as to possible increase in efficiency or speed. I have known cases where probable speeds with novel propellers have been estimated or guessed to the third place of decimals.

In one instance a trial was made with the new propeller, with the result that, instead of a gain in efficiency, there was a serious loss of speed. Very few of the proposals made have merit enough to be subjected to trial. None of them can possibly give the benefits claimed. It need hardly be added that, in speaking thus of so-called "inventors," there is no suggestion that improvement has reached its limit, or that further discovery is not to be made. On the contrary, in regard to the forms of ships and propellers, continuous investigation is proceeding and successive advances are being made. From the nature of the case, however, the difficulties to be surmounted increase as speeds rise; and a thorough mastery of the past history and present condition of the problems of steamship design and propulsion

is required as a preparation for fruitful work in the nature of further advance.

It would be idle to attempt any predictions as to the characteristic features of ocean navigation sixty years hence. Radical changes may well be made within that period. Confining attention to the immediate future, it seems probable that the lines of advance which I have endeavored to indicate will remain in use. Further reductions may be anticipated in the weight of propelling apparatus and fuel in proportion to the power developed; further savings in the weight of the hulls, arising from the use of stronger materials and improved structural arrangements, improvements in form and enlargement in dimensions. If greater draughts of water can be made possible, so much the better for carrying power and speed. For merchant vessels commercial considerations must govern the final decision; for warships the needs of naval warfare will prevail.

It is certain that scientific methods of procedure and the use of model experiments on ships and propellers will become of increased importance. Already avenues for further progress are being opened. For example, the use of water-tube boilers in recent cruisers and battleships of the Royal Navy has resulted in saving one-third of the weight necessary with cylindrical boilers of the ordinary type to obtain the same power, with natural draft in the stokeholds. Differences of opinion prevail as to the policy of adopting particular types of water-tube boilers, but the weight of opinion is distinctly in favor of some type of water-tube boiler in association with the high steam pressures now in use. Greater safety, quicker steam raising and other advantages, as well as economy of weight, can thus be secured. Some types of water-tube boilers would give greater saving in weight than the particular type used in the foregoing comparison with cylindrical boilers. Differences of opinion prevail, also, as to the upper limit of steam pressure which can, with advantage, be used, taking into account all the conditions in both engines and boilers. From the nature of the case, increases in pressure beyond the 160 pounds to 180 pounds per square inch commonly reached with cylindrical boilers, can not have any-

thing like the same effect upon economy of fuel as the corresponding increases have had, starting from a lower pressure. Some authorities do not favor any excess above 250 pounds per square inch on the boilers, others would go as high as 300 pounds, and some still higher.

Passing to the engine rooms, the use of higher steam pressures and greater rates of revolution may, and probably will, produce reductions in weight compared with power. The use of stronger materials, improved designs, better balance of the moving parts and close attention to details have tended in the same direction without sacrifice of strength. Necessarily there must be a sufficient margin to secure both strength and endurance in the motive power of steamships. Existing arrangements are the outgrowth of large experience, and new departures must be carefully scrutinized. The use of rotary engines, of which Mr. Parsons' turbomotor is the leading example at present, gives the prospect of still further economies of weight. Mr. Parsons is disposed to think that he could about halve the weights now required for the engines, shafting and propellers of an Atlantic liner, while securing proper strength and durability. If this could be done in association with the use of water-tube boilers it would effect a revolution in the design of this class of vessel, permitting higher speeds to be reached without exceeding the dimensions of existing ships. It does not appear probable that, with coal as the fuel, water-tube boilers will surpass in economy the cylindrical boilers now in use; and skilled stoking seems essential if water-tube boilers are to be equal to the other type in rate of coal consumption. The general principle holds good that as more perfect mechanical appliances are introduced, so more skilled and disciplined management is required in order that the full benefits may be obtained. In all steamship performance the "human factor" is of great importance, but its importance increases as the appliances become more complex. In engine rooms the fact has been recognized and the want met. There is no reason why it should not be similarly dealt with in the boiler rooms.

Liquid fuel is already substituted for coal in many steamships. When sufficient quantities can be obtained, it has many obvious

advantages over coal, reducing greatly manual labor in embarking supplies, conveying it to the boilers, and using it as fuel. Possibly its advocates have claimed for it greater economical advantages over coal than can be supported by the results of extended experiment. Even if the saving in weight for equal evaporation is put as low as 30 per cent. of the corresponding weight of coal, it would amount to 1,000 tons on a first-class Atlantic liner. This saving might be utilized in greater power and higher speed, or in increased load. There would be a substantial saving on the stokehold staff. At present it does not appear that adequate supplies of liquid fuel are available. Competent authorities here and abroad are giving attention to this question, and to the development of supplies. If the want can be met at prices justifying the use of liquid fuel, there will undoubtedly be a movement in that direction.

Stronger materials for the construction of hulls are already available. They are, however, as yet but little used, except for special classes of vessels. Mild steel has taken the place of iron, and effected considerable savings of weight. Alloys of steel with nickel and other metals are now made, which give strength and rigidity much superior to mild steel, in association with ample ductility. For destroyers and torpedo boats this stronger material is now largely used. It has also been adopted for certain important parts of the structures of recent ships in the Royal Navy. Of course, the stronger material is more costly, but its use enables sensible economies of weight to be made. It has been estimated, for example, that in an Atlantic liner of 20 knots average speed about 1,000 tons could be saved by using nickel-steel instead of mild steel. This saving would suffice to raise the average speed more than a knot, without varying the dimensions of the ship. Alloys of aluminum have also been used for the hulls or portions of the hulls of yachts, torpedo boats and small vessels. Considerable savings in weight have thus been effected. On the other hand, these alloys have been seriously corroded when exposed to the action of sea water, and on that account are not likely to be extensively used. Other alloys will probably be found which will be free from this defect, and yet unite lightness with strength to a remarkable degree.

Other examples might be given of the fact that the metallurgist has by no means exhausted his resources, and that the shipbuilder may look to him for continued help in the struggle to reduce the weights of floating structures.

It is unnecessary to amplify what has already been said as to possible increase in the efficiency and types of propellers. With limited draught, as speeds increase and greater powers have to be utilized, multiple propellers will probably come into use. Mr. Parsons has shown how such problems may be dealt with; and other investigators have done valuable work in the same direction. In view of what has happened, and is still happening, it is practically certain that the dimensions of steamships have not yet attained a maximum. Thanks to mechanical appliances, the largest ships built, or to be built, can be readily steered and worked. In this particular difficulties have diminished in recent years, notwithstanding the great growth in dimensions. Increase in length and weight favor the better maintenance of speed at sea. The tendency, therefore, will be to even greater regularity of service than at present. Quicker passages will to some extent diminish risks, and the chance of breakdown will be lessened if multiple propellers are used. Even now, with twin screws, the risk of total breakdown is extremely small.

Whatever may be the size and power of steamships, there must come times at sea when they must slow down and wait for better weather. But the larger and longer the vessel, the fewer will be the occasions when this precaution need be exercised. It must never be forgotten that as ships grow in size, speeds and cost, so the responsibilities of those in charge increase. The captain of a modern steamship needs remarkable qualities to perform his multifarious duties efficiently. The chief engineer must have great powers of organization, as well as good technical knowledge, to control and utilize most advantageously the men and machinery in his charge. Apart from the ceaseless care, watchfulness and skill of officers and men, the finest ships and most perfect machinery are of little avail.

The "human factor" is often forgotten, but is all-important. Let us hope that in the future, as in the past, as responsibilities increase so will the men be found to bear them!

COATINGS FOR CAST-IRON WATER PIPES.*

By Thomas H. Wiggin.

It is probable that nearly every engineer who has had a large number of pipes to lay has resolved that he will do something to dispel the mist that hangs about the subject of preservative coatings. Very many seem to have made concoctions of coal tar, asphalt, linseed oil and other things, in the endeavor to strike the fortuitous combination of cheap products which would adequately protect the metal. If all these experiments could be published the engineering world might finally arrive at a choice by rejection. As it is, the same ground is covered several times over with the same disappointing results. The question of preservative coatings belongs properly to the skilled chemist, but it has been attacked with some assurance by persons (including the writer) who are not chemists. The results of the writer's observation, study and experiment, made in connection with the Metropolitan Water Works, will be given.

COAL-TAR COATING.

The inspector having passed judgment on the pipes, they are rolled along down to the coating apparatus. The apparatus consists of a number of ovens, with iron cars, on which the pipes are rolled into the oven and on which they stand during heating, a vat or tank for the coating compound, a crane for hoisting the pipes in and out of the vat, and various brushes, scrapers and mops for brushing out dirt and removing surplus coating material. The coating material is crude gas tar with sometimes some dead oil of tar added. The pipes are given a fairly good brushing before being put in the oven. The oven is

* Extracted from a paper on "The Manufacture and Inspection of Cast-Iron Pipes," read before the Boston Society of Civil Engineers.

merely an enlarged chimney flue, for all the smoke and gases of combustion pass in at one part and out at another, so that a light, but visible deposit of soot is made on the pipes, which is not brushed off. The old-fashioned ovens have simply a square hole through the floor of the oven connecting it with the fire, so that the hot gases, and occasionally flame, act principally upon one portion of the pipe, heating that portion very hot before materially affecting the other portions. The newer ovens are fitted with an arched bottom, with bricks left out at intervals all along the pipe, this arrangement causing a more uniform temperature. The pipe is left in the oven until the attendants think (no thermometer is used) it is heated to about the correct temperature (48-inch pipes are left in about 20 minutes); then it is put in the tar to stay from a moment to 10 minutes, according to the condition of the work about the vat. On being removed from the vat, the pipe is allowed to drain over the vat, and the drainage is aided by scraping the invert with a segmental hoe, made to fit, or at least to be of smaller radius, than the pipe. The pipe is then lifted out on to skids and the coating smoothed up further —surplus tar removed and thin places reinfored—by a brush or a mop. The brush is better, because the mop leaves part of itself behind on each pipe. The coating becomes hard in from one-half to two hours, according to conditions.

Coal tar is a very complex mixture; indeed, the fact is so well known that people are not seldom heard calling a doubtful drug "one of those coal-tar products." Moreover, coal tar varies very widely according to the coal used and the temperature maintained in the manufacture of the gas. Furthermore, crude tar varies at different heights in the tank in which it is collected at the gas works. But no tests are made to obtain any particular kind of tar for coatings. The unrefined overflow from the hydraulic main of the gas plants is purchased where it can be obtained easiest and cheapest. Specifications often call for deodorized tar, but the most noticeable thing about coating tar is its dense and pungent fumes when heated.

The degree of the fluidity of the tar varies with the composition and with the temperature. In summer tar is usually more

fluid than molasses; in winter it has often to be melted out of the barrels. This crude tar cannot be used as a paint for cold surfaces, because it will not harden. Tar from the coating vat, though always somewhat refined by the continued heating, does not harden sufficiently when applied to cold surfaces. This suggests the philosophy of the whole tar process of coating. By the heat of the pipes the tar is distilled down to a compound which is solid at atmospheric temperatures. A very favorable condition for this volatilization of the liquefying constituents (which are also the most volatile constituents) evidently exists when the tar is exposed to the air, spread, as it is then, in a thin film over the hot pipes; and that rapid volatilization takes place at this time is indicated by the dense fumes given off.

As a corollary to the foregoing, it follows that the temperature of the pipe, as it emerges from the tar bath, is one vital factor in the character of the coating. If the pipe is too hot, the coating is over-distilled and becomes too brittle, or may even be reduced to an earthy, carbonaceous residuum. If the pipe is too cool, a thicker coating is formed, which will not harden sufficiently, will come off in the skids and will run in warm weather. Thin pipes must be heated hotter than thick pipes, because the thin metal does not hold the heat so long, and hence the distillation must be more rapid at first. The writer made an attempt to measure the temperature of some pipes just before they were dipped. An ordinary thermometer was, of course, of no use, nor could an electrical device be found which experts would recommend to record such low temperatures. Hence, the writer procured several chemicals which are said to pass through noticeable changes at certain fixed temperatures: red iodide of mercury, which is said to change to the yellow at about 300 degrees Fahrenheit; yellow stick sulphur, which fuses at about 235 degrees Fahrenheit, and silver nitrate, which fuses at 424 degrees Fahrenheit. Every pipe which was tried turned the red mercuric iodide to the yellow form, but no pipe, apparently, fused the silver nitrate. The effect on the latter and on the sulphur was hard to observe on account of the heat and smoke; hence, the only conclusion that could safely be drawn was that

pipes, just before coating, are usually considerably over 300 degrees Fahrenheit. With tar and thickness of pipe so variable, the proper temperature must be a matter of judgment on the part of the dipman. A reliable and handy pyrometer would help, however, as it would enable the dipman to use the experience gained on one pipe in judging of the next one.

There is no question about the importance of having ovens properly arranged to heat the pipes uniformly. The brick fire arch, having bricks left out at intervals all along the position of the pipe, is rather satisfactory. The single opening at one end of the pipe is decidedly unsatisfactory. The soot that is deposited on the pipes may do some harm. More elaborate and more nearly perfect schemes for heating pipes will quickly suggest themselves, but it seems probable that a careful application of the present methods will give results as satisfactory as a crude tar coating warrants. Careless application will vitiate any method. Thus, at one foundry the pipes are often wittingly underheated on days when strong northerly winds prevail, because the wind makes it difficult to heat the ovens, and the day's work must be done just the same. Again, the pipes which stay in the oven during the dinner half hour are liable to go into the tank too hot, because they are left in the oven too long and are not allowed to cool down. In general, the men fall into a certain routine of work—so many pipes to brush out, so many to mop out, so many to roll into the oven, etc., between dippings, and this routine fixes the time of heating. A good dipman will not allow very noticeable errors in temperatures to pass, but he will not delay the routine for minor errors. In other words, the application of the method is inferior to the best judgment of the dipman.

The character of the tar in the bath is another important variable. New tar gives softer coatings, other things equal, because it contains more of the lighter constituents. Thick tar gives thicker coatings than thin tar. The temperature of the pipe should be varied to meet variations in the coating compound. Fresh tar requires a hotter pipe than does old tar. Regularity in aiding new tar would give greater uniformity in coatings, but

tar is often not in stock when it is needed, and the dipman does not care much, so long as the coating passes—and the inspectors do not usually pretend to know much about coatings or to judge them very harshly.

The temperature of the tar itself does not count for much when the pipes are heated before being dipped, as is universal now. In the old method of heating the pipes by allowing them to remain in the dip half an hour or so, the temperature of the dip was very important, though less so than it would have been with crude tar. The temperature of the tar in the present method is usually about 220 to 230 degrees Fahrenheit. Observations of men at the foundry on temperature of the dip, and the writer's observations on small quantities of tar, indicate that new tar, on account of the lighter constituents,* does not at first rise above 220 degrees Fahrenheit. Later it rises to 350 degrees Fahrenheit, if heated sufficiently. It is evident that the old method of allowing the pipes to come to their proper temperature in the dip would lead into difficulty if the crude tar was fresh in the tank, as it would be difficult or impossible to raise the pipes to the required 300 degrees or more.

Small pipes are, as a rule, carelessly heated, and the writer has often seen very hot pipes lowered into the tank, where they caused a violent boiling and much yellow smoke (yellow smoke is the founder's sign of an excessively hot pipe). An inspector said that at one foundry pipes hot enough to set fire to the tar are so common that lids are rigged so that they can be rapidly unhooked and allowed to fall over the tank and smother the flames.

DEAD OIL.

Specifications often call for the use of dead oil of coal tar in the dip. Dead oil is defined as that part of coal tar which is obtained, in fractional distillation of coal tar, between the temperatures of 410 and 750 degrees Fahrenheit, approximately. It

* The law of fractional distillation is that a mixture, when distilled, remains at the boiling temperature of that constituent which boils at the lowest temperature until that constituent is gone; then rises to the next lowest boiling point and remains there, and so on.

contains both the creosote and the anthracene oils. Whether the commercial article agrees with this definition is unknown to the writer.

Some commercial dead oil that the writer tried evaporated about one-seventh as rapidly as water, both being exposed to the air. A brown cake was left in the bottom of the vessel. The misconception is probably often entertained that dead oil bears to tar coating a relation similar to that of linseed oil to paint. A better comparison would be that between dead oil in coal tar and turpentine in paint. Dead oil is of use principally to thin back the tar when it becomes thicker than the dipman likes it. Ordinarily, the necessary adding of fresh tar is sufficient to keep the tar thin. At one foundry no dead oil would ever be used if the engineer did not occasionally require it. At another foundry it is the regular practice to use one barrel of dead oil to about seven of coal tar. A change was made at one foundry from no dead oil to about the above proportions, but it had no visible effect on the character of the coating. The effect on the composition of the tar dip was to increase the proportion of the heavy oils in the tar from about 25 to about 35 per cent., and perhaps the change really did improve the coating.

TAR AND LINSEED OIL.

The use of linseed oil in tar coatings dates back to the first tar coating of Dr. Robert Angus Smith, a patent for which was taken out in Great Britain in 1848. The patent states that pipes were first to be cleaned and then preferably coated with linseed oil. Pipes might be heated before dipping, or allowed to come to a heat in the mixture. The tar was distilled to "a thick, pitch-like mass," and kept at a temperature of about 300 degrees Fahrenheit. Pipes were left in the dip about thirty minutes. Dr. Smith found it "desirable to pour a quantity of linseed oil on the coated surfaces," which process had "the effect of removing any excess of tar, and the oil running into the tar kept it fluid and prevented its becoming unsuitable for further use." Such was the first coating of Dr. Smith. The writer found several different coatings described as Dr. Smith's, and it is probable that the

doctor improved on his original one. The foundrymen to-day often call the crude-tar coating in present use "the ordinary Angus Smith coating." In "Water Supply of Cities and Towns," by William Humber (1876), two methods used by Dr. Smith are given. In both the dip contained gas tar, Burgundy pitch, oil and resin, the percentage of linseed oil in the second method being five or six. In the first of these methods the pipes were heated to from 400 to 500 degrees Fahrenheit, and the dip also was kept hot. In the second, the dip only was heated, and the pipes were allowed to take the temperature (300 degrees Fahrenheit) of the dip. It was supposed that the pores of the iron opened to receive the tar.

The questions that concern us now are whether linseed oil improves the quality of tar coating, and, if so, what method can be adopted for its use. On the first question we seem, as usual, to have no direct evidence. Old foundrymen will say that the present coating is not so good as the former coating was, but there are no comparative records available, so far as the writer knows. The writer has been unable to find out from records, or by questioning foundrymen, how much and in what ways linseed oil was used in the past, and when it ceased to be used. One very intelligent employee, who had been in the foundry business for about twenty years, thought there had been no linseed oil used at the foundries around Philadelphia since about 1872. Specifications throw little light on the subject, as they often contain directions that are not followed. It seems probable that the practice of using linseed was gradually dropped, perhaps on account of a change in the character of the tar obtained from the gas works, perhaps for other reasons of convenience; perhaps with the knowledge and consent of engineers, and perhaps without their knowledge. At any rate, the comfortable feeling of a question pretty well solved has continued; though perhaps, if the truth were known, the modern crude-tar coating would be found to be living on the hardearned reputation of the linseed oil coating. If records of the composition and behavior of coatings had been carefully kept and made available to students of the subject, many years of experience, now of little use, would have

been saved to the world; and unless more care is taken, the next generation will make the same complaint.

In default of sufficient experience, we must resort to theory. The japan coating of Edward Smith & Co. is the result of careful theorization,* and the pamphlets issued by that firm containing articles by Mr. A. H. Sabin, chemist for the firm, and by others, give many facts in regard to preservative coatings. Mr. Sabin puts up a very strong plea for linseed oil, but he discards coal tar as a filler, and accepts copals and also asphalt, which chemists usually consider as a more enduring compound than the complex and volatile coal tar. Mr. Sabin is also enabled to use a large percentage of linseed, and without any injurious dryer, because he bakes his coating. Now, whether or not the asphalt is better than tar, the arguments brought forth for the use of linseed seem pretty strong, and the writer would make use of them to give some evidence that linseed oil would improve coal-tar coating.

Assuming, at any rate, that linseed oil would improve tar coating, the writer attempted to find out how it could be successfully applied to the present practice. At the McNeal foundry an experiment had just been tried with an imported English tar and raw linseed, the fact that crude American tar could not be used with linseed having been proved at this foundry in previous years. The English tar was said to be somewhat refined, but appeared about the same as the American crude tar. The tar pit was cleaned out and English tar and raw linseed, in the proportions of ten tar to one linseed, were put in. The mixture became thick and lumpy, and all efforts to make a passably smooth coating failed. Even a temperature of 350 degrees Fahrenheit failed to improve matters, and pipes had to be recoated. No more linseed was added to the dip, but fresh tar and dead oil were added as needed, so that the proportions of linseed steadily grew less. Finally the tank was cleaned out and the use of crude American tar resumed.

The following is a description of some of the experiments tried by the writer with tar and linseed: The mixtures were

* Also of much experience, though not with conditions such as exist in water pipes.

made mostly in ten-quart porcelain-lined kettles. The specimens coated were fragments of pipes, the pieces being usually about 3 to 5 inches wide and 0.5 to 1.25 inches thick.

(1) Twenty-eight parts of English tar and one part of raw linseed. The linseed, cold, was added to the tar at 240 degrees Fahrenheit. Violent frothing took place. The mixture soon doubled its volume and ran over. Coating out of the question for practical use on account of frothing and lumpiness.

(2) Twenty-eight parts English tar, plus three parts raw linseed that had been boiled for ten minutes. Ingredients mixed with tar cold and brought to liquid state at about 340 degrees Fahrenheit.* Less frothing than before, but coating useless. Soft oil collected next the iron, and dull, earthy tar outside. Dead oil helped matters somewhat, but coating remained useless.

(3) Twenty-eight parts English tar, plus one part commercial boiled linseed (guaranteed by an acquaintance as not having been boiled "through the bung-hole"). At 230 degrees Fahrenheit violent frothing occurred, and, though a fairly good coating was obtained on a small scale, the method is out of the question for regular work. Dead oil did not help.

The foregoing experiments indicated that such crude tar could not be used.

(4) In order to get tar at least somewhat refined, took 4 quarts of tar from the coating tank. Added ¼ quart of boiled linseed oil thereto. Frothing was too vigorous for any thought of practical application.

(5) Boiled some crude tar for about 5½ hours. At the start, the tar was a thin fluid at atmospheric temperature. After boiling, the tar was a soft solid at atmospheric temperature. During boiling, the temperature of the tar remained at about 220 degrees Fahrenheit for about an hour, then rose to about 290 degrees and stayed there for a time, and finally became about 350 degrees.

To sixteen parts of this boiled tar, added one part of boiled linseed. No frothing occurred, even at 400 degrees Fahrenheit.

* This temperature seems abnormally high in view of the other results.

The mixture was thick and did not harden sufficiently on fragments of ½-inch pipes. Later it occurred to the writer to try thick pipes (an inch or more thick), and there was no difficulty in getting the coating even too hard. No frothing occurred when dead oil was added to thin the mixture.

The experiment showed that linseed oil could be used with partially refined tar, but it also indicated that the application of the method required more intelligent care than does the crude-tar method.

Since making these experiments, the writer has found an old specification for tar coating, the method of which agrees so closely with the results of these experiments that the following quotation is made.* "The varnish, or pitch, is to be made from coal tar, distilled until all the naphtha is removed, the material deodorized and the pitch reduced to about the consistency of wax or very thick molasses. At least 8 per cent. of heavy linseed oil must be added." It is rather humiliating to come back to the results of thirty years ago. It would not be so if the old method had been deliberately abandoned for a better one; but, as already intimated, it is not apparent that such was the case.

Refined tar is now out of the market, though a tar residuum or pitch is used in roofing and for walks. As the above experiment indicates, it would be an easy matter to make some refined tar.

Procured some of the roofing pitch mentioned above. It is a solid, just viscous enough to slowly find its level in warm weather, but hard and brittle in cold weather.

(6) Roofing pitch alone. Coating was thick and very glossy, but, of course, rather brittle. Such a coating might give excellent results if handled only in warm weather, but would probably fly off in cold. This coating has stood water tests for about a couple of years without losing its smoothness and luster.

(7) Nine parts of roofing pitch and one of boiled linseed. A thick, glossy coating, not so brittle as pitch alone.

(8) Nine parts pitch to two boiled linseed. Better than seven as regards brittleness.

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* See Report of the Cochituate Water Board, 1867–68, p. 17.

(9) Nine parts pitch to three boiled linseed. Coating more bulky and less smooth than the others.

A greater proportion of the linseed would make the coating like paint, and drying would be too slow, unless baking were resorted to, as in the Sabin japan.

ASPHALT COATINGS.

It is truly charged against coal tar that it continues to decompose, so that finally nothing but a friable, earthy pitch is left. It is said to be characteristic of pyrogenic (fire-formed) compounds, to which class coal tar belongs, that they are unstable at ordinary temperatures. Asphalt also decomposes with exposure, as demonstrated at the natural asphalt lakes, but, nevertheless, is thought to be more durabe than coal tar. The only direct long-time comparisons that occur to the writer are in the matter of walks and pavements, and here there is no doubt that the asphalt has demonstrated its superior durability. However, the conditions in a water pipe are different from those of a street surface; moreover, a coating material might be very durable in itself and yet not form an impervious coating, as is the case with pure linseed oil used alone. Asphalt has not the aggressive penetration of coal tar, nor does it stick to things and cover everything so persistently as tar. A little drop of tar will smirch skin, clothes, paper and everything that comes near it, without apparent diminution in size, while asphalt can be handled with impunity.

The usefulness of asphalt as a pipe-coating compound for cast iron has never been demonstrated, though asphalt has been, and is still, used largely in coating steel pipes. Some information on its success for steel pipes should be available by this time, but little has been published.

The writer tried many experiments with Alcatraz, or California asphalt. Grades of several degrees of hardness are made, and by mixing grades it is comparatively easy to get a good consistency. A temperature of about 260 degrees Fahrenheit was needed. The coating is not brittle, not very smooth, rather dull and not very tenacious. In fact, the impressions of the coating

were rather of a negative nature. There were no glaring defects in the coating, neither was it very attractive.

Linseed mixes well with asphalt, but the coating does not harden unless a hard grade of asphalt is used.

P. & B. PIPE DIP.

This is a patent dip manufactured by the Standard Paint Company. Its principal ingredients probably are asphalt and candle-tar pitch. The latter is a pitch obtained by distillation of animal fats. This coating has been used somewhat on steel pipes, but not long enough for a test of durability. As applied to cast iron it gives a coating very similar to asphalt coating—not hard, not brittle, not very glossy, not very tenacious.

MINERAL RUBBER DIP.

This is a dip manufactured by the Assyrian Asphalt Company. The process is not patented, but is secret. The appearance indicates that the compound is largely asphalt, and the coating is somewhat similar to asphalt coating, only duller in appearance. The dip requires a temperature of about 400 degrees Fahrenheit. This dip has recently become very popular for steel pipes.

VARNISHES.

There are many cheap varnishes made from tar, and there are also more expensive ones containing asphalt and other ingredients. These varnishes consist of some solid dissolved in a volatile carrier, which quickly evaporates, leaving the solid on the coated body. The engineers of the Metropolitan Water Works have used a number of these varnishes in painting over the coal-tar coating, with the idea of filling up the pores in the coating. The writer has experimented with some of these varnishes.

(1) P. & B. Universal Paint, manufactured by the Standard Paint Company. This is to many a very familiar varnish, because it is not forgotten after having been once used. The solvent contains carbon disulphide, the odor of which is sickening to

most persons. The coating seems fairly good after it is on, but the odor interferes with its use.

(2) P. & B. Ruberine, also manufactured by the Standard Paint Company. This varnish consists of "ruberoid" dissolved in naphtha. Ruberoid consists of California asphalt and candle-tar pitch digested and vulcanized with sulphur. Ruberine dries rapidly and is hard to spread smoothly. It gives, however, a substantial rubbery coating.

(3) Tar varnishes. Two of these were tried, one an American and the other a Dutch product, imported by Paul A. Davis, of Philadelphia, and said to be much used abroad. The varnishes were thin, had the coal-tar penetration, and gave smooth, good-looking coatings.

It is evident that the use of varnishes would be very limited, unless it were found possible to use them as dips; their rapid evaporation seems to preclude their use in this way; but trial alone, and on a large scale, would settle this question.

TESTS OF COATINGS.

Of course, the only satisfactory test of coatings is actual use under known conditions. Small-scale experiments are often misleading and always inconclusive. Moreover, all coatings are so durable that it takes a number of years to form an idea of their relative value, and by that time something new is often favored on theoretical evidence. However, the small specimens used in the experiments above described were subjected to several tests.

(1) Test for brittleness. Most of the specimens were tested by hammering to see whether the coating was liable to fly off in handling of pipes. Allusion to brittleness has been made in describing the coatings.

(2) Test of porosity. It is known that tubercles start at minute holes in coating. It was thought that if acid did not injure the coating material itself, it would give a test of the porosity of coatings by attacking the metal through the pores. Specimens of coated iron were put in glass jars containing a mixture of one part muriatic acid and two parts water. At the same time samples of the coating materials alone were put into other glass jars

with acid of the same strength. Great activity was immediately apparent in the case of the coated iron, and a disagreeable gas with a sweetish odor was evolved. The coating materials alone, on the other hand, were apparently not acted upon. Their appearance, and the appearance of the acid in which they were submerged, remained the same to the end of the test, which was almost as long as the test of the coated iron.

The coatings were all badly undermined, and all but a specimen of Sabin's japan peeled off in many places. The iron was dissolved to a depth of $\frac{1}{8}$ inch in places, especially at the corners. The estimate that was placed upon the specimens, beginning with the least injured, is shown by Table I.

TABLE I.—ACID TESTS OF COATINGS FOR POROSITY.

	Coating.	Time exposed, days.	Remarks.
1.	Sabin Japan	55	Specimen said to have been rusty before being coated.
2.	Crude tar	55	.....
3.	Tar and linseed	60	No distinction possible.
	Alcatraz asphalt, pitch and linseed	60	
	Mineral dip (Assyrian Asphalt Co.)	55	
	P. & B. dip (Standard Paint Co.)	55	
4.	Alcatraz asphalt	55	.....
5.	All the varnishes	55	Totally destroyed.

There was only one specimen of each coating.

(3) Running-water test. The specimens indicated in Table II have been kept in running Boston water. Many tubercles have already formed on corners and on the rough fractured edges, but only a few* on the smooth large faces that formed parts of the inside and outside, respectively, of the pipes from which the specimens of iron were broken. The writer's estimate of the coatings is given in Table II.

* This does not include the numerous tubercles, due perhaps to galvanic action, that were formed at many places along the copper wire wound around the specimens to suspend them by.

TABLE II.—RESULTS OF EXPOSING COATINGS TO RUNNING WATER.

Coating.	Time exposed, years.	Remarks.
1. Tar and linseed.....	2	Coating is smooth and in good condition, except for group of five ¼-inch tubercles.
2. Mineral dip.....	2	Few tubercles on large surfaces, but coatings rather earthy.
P. & B. dip.....	2	
3. Alcatraz asphalt.....	2	Badly tubercled; covered with crumbling blisters.

There was only one specimen of each coating.

The samples indicated in Table III have endured four months in running Delaware River water, whereby they were scarcely tubercled at all, but received a heavy coat of mud washings to remove the mud, and finally seventeen months in running Boston water, where they still are. The specimens have only three to five incipient tubercles* and a few specks on the large surfaces, though there are a good many well-developed tubercles, as usual, on the rough edges of fracture, and around the copper suspension wire. In general appearance the writer would rank them as is Table III.

TABLE III.—RESULTS OF EXPOSING COATINGS TO RUNNING DELAWARE RIVER WATER FOR FOUR, AND BOSTON WATER FOR SEVENTEEN MONTHS.

Coating.	Remarks.
1. Pitch.....	Coating still glossy.
2. Pitch and linseed.....	
3. Pitch and linseed, painted with Dutch varnish.	
4. Mineral dip.....	Tubercles not more numerous than in the case of the foregoing specimens; surfaces rather earthy in appearance, and not smooth.
P. & B. dip.....	
5. Dutch varnish.....	Freer from tubercles than any of the other specimens; surface is earthy and friable, black powder being easily scraped off.

There was only one specimen of each coating.

*A piece of pottery coated with Dutch varnish was not tubercled at all. This corresponds with the generally accepted idea that iron is essential to the formation of tubercles.

The specimens in Table IV, endured the same treatment in Delaware water and subsequent washing off of mud, and were finally placed in a tank of water that is not often changed, where they have been about fifteen months. The tank has been used for much of the time for cement briquettes, and the water is hence very alkaline.

TABLE IV.—RESULTS OF EXPOSING COATINGS FIRST TO RUNNING WATER AND THEN TO ALKALINE WATER, SELDOM CHANGED.

	Coating.	Remarks.
1.	Pitch	Good condition; few tubercles.
2.	Tar covered with Dutch varnish	
3.	Tar and linseed	
4.	Alcatraz asphalt, pitch and linseed	
	Tar	
5.	Mineral dip	In fair condition.
	Alcatraz asphalt and linseed (two specimens)	
	Alcatraz asphalt, pitch and linseed (specimen)	
	P. & B. paint (two specimens)	Few tubercles; coatings rather earthy; black will rub off.
	Dutch varnish	
6.	Mineral dip (another specimen)	Bad condition; many well-developed tubercles; also crumbling blisters.
	P. & B. dip	
	Alcatraz (two specimens)	

There was only one specimen of each coating, except in the cases specially noted above.

TABLE V.—APPROXIMATE RELATIVE COST OF VARIOUS COATINGS.

Coating.	Approximate amount required to coat one 48 inch pipe.	Approximate price.	Cost of material, one 48-in. pipe.
Crude tar	3¾ gallons.*	$3.00 per bbl. (52 galls.)	$ .22
Pitch	5 "	5.00 " " "	.50
Pitch and linseed	.....	.....	.70
P. & B. dip	20 pounds.	$45.00 per ton.	.45
Mineral dip	20 "	75.00 " "	.75
P. & B. Univ. paint	1½ gallons.	1.00 per gallon.	1.50†
P. & B. ruberine	1½ "	1.00 " "	1.50†
Tar varnish	1½ "	.10 " "	.15†
Dutch varnish	1½ "	.25 " "	.40†
Sabin japan	1½ "	1.75 " "	2.60‡

*About 30 per cent. of this lost by evaporation.

†Estimated cost of the coating applied as by a brush. Wastage might be excessive as dip, but the latter would be the only practical way for use on a large scale; hence the figures above are not strictly to the point.

‡This coating requires a comparatively expensive plant and considerable skilled labor, which would largely increase the total cost.

Table V gives a very rough idea of the relative cost of the various coating materials. The crude tar results are based on actual records and are believed to be reasonably close. The other results are mere estimates, based, in the case of the dips, on the results for tar; in the case of the varnishes on estimated covering capacity; and in the case of the Sabin japan on results for steel pipes.

CONCLUSIONS.

Should the Sabin japan prove by use to be as good as it appears to be, engineers would have to decide whether it were economical to add from 5 to 10 per cent. to the cost of pipes in order to prevent in part a deterioration, in the carrying capacity, which has been found as large as 20 per cent. in 16 years in even large pipes.* But the efficacy of the coating must be proved by several years of use.

As for the above tests, the tar compounds seem to have the best of them on the whole (barring the Sabin japan, which was tested only by acid), though the tests are too few and too short to serve as a basis for decided opinions. The writer would like to try roofing pitch on some pipes. He has considerable faith in the efficacy of thick, smooth coatings, such as it makes. The experiments show that only a thick coating will protect rough surfaces and corners. If the pitch proved too brittle to stand the handling of shipping and carting, it would not be impossible to have a portable coating outfit. The writer would also like to see a refined-tar and linseed-oil coating tried on the commercial scale. He would suggest that it would not be a very expensive experiment for a large city to try the several coatings on some line of its pipes and thus determine in a national way what coating was best for its water.

Rusty pipes will apparently not hold a coating. At one foundry were several 30-inch pipes having only little blotches of tar coating left on them. The writer was told that these pipes were coated only two years before, but were very rusty when coated.

* See paper by Desmond FitzGerald, Mem. Am. Soc. C. E., Trans. of Am. Soc. C. E., Vol. XXXV, 1896, p. 241.

The foundry scale which forms the surface of castings will protect the castings from rust for some time. Even when a casting is allowed to stand in a shower or two, only streaks of rust on top are formed at first. All chipped surfaces, however, quickly rust, and it is noticeable that coating over chipped surfaces is often quickly destroyed. Whether this is due to the surface being rusty before coating, or to a poor adhesion of the coating to even clean chipped surfaces, is unknown to the writer.

THE THERMAL EFFICIENCY OF STEAM ENGINES.

One of the most important engineering papers published in recent years was the report of the committee appointed by the Institution of Civil Engineers to consider and report to the council upon the subject of the definition of a standard or standards of thermal efficiency for steam engines. We print the main portion below as given in the Proceedings of the above society.—ED.

INTRODUCTORY NOTE.—PREPARED AT THE REQUEST OF THE COUNCIL, BY CAPTAIN SANKEY.

The following report assumes a competent knowledge of thermo-dynamics, and some explanation may therefore be of use to those who have not this knowledge, but yet are interested in steam-engine economy. For this purpose the following introductory note has been drawn up to show what it has been desired to measure and to compare.

A steam plant in its simplest form normally consists of:

(1) The boiler, with its feed arrangements, to produce the steam.

(2) The pipes to conduct the steam to the engine.

(3) The engine to transform a portion of the steam energy into work upon the pistons.

Further the plant may include:

(4) A condenser with an air pump or equivalent apparatus, which must be added if the engine is to be relieved from the back pressure due to the atmosphere.

(5) An economizer may be added to the boiler to improve its performance by transmitting to the feed water some of the heat which would otherwise escape up the flue.

(6) A feed heater may be used in the case of a non-condensing engine, to recover some of the waste heat in the exhaust steam.

(7) Steam jackets and reheaters are added to the engine under certain circumstances.

No portion of a steam plant is perfect, and each is the seat of losses more or less serious. If, therefore, it is desired to improve the steam plant as a whole, it is first of all necessary to ascertain separately the nature of the losses due to its various portions; and in this connection the diagrams in Plate 5 have been prepared, which it is hoped may assist to a clearer understanding of the nature and extent of the various losses.

The boiler, the engine, the condenser and air pump, the feed pump and the economizer, are indicated by rectangles upon the diagram. The flow of heat is shown as a stream, the width of which gives the amount of heat entering and leaving each part of the plant per unit of time; the losses are shown by the many waste branches of the stream. Special attention is called to the one (unfortunately small) branch which represents the work done upon the pistons of the engine.

It is obvious that with so many channels of loss, it is of the utmost importance that the circumstances under which they arise, and their amount, should be ascertained and considered separately. It is also especially useful to ascertain the exact amount of those losses which are inevitable according to the laws of Nature, and to distinguish them from other losses, also to some extent inevitable but yet capable of reduction by improvement in design or in material. It is shown in the diagram, by the stream which goes from the engine towards the condenser, that by far the greatest loss occurs in the engine; and this circumstance, coupled with the fact that the design and manufacture of steam engines form a distinct and almost separate branch of engineering, give ample ground for isolating the engine and considering it apart from other portions of the steam plant.

For this reason the report does not deal with the steam plant as a whole, but only with the steam engine proper, which is defined in the report as consisting of "everything included between the boiler side of the engine stop valve and the exhaust flange."

Much diversity of opinion has existed as to the method of

stating the thermal economical value of an engine and the standard with which it should be compared. The work of the committee has been directed to these points.

The upper diagram in the plate represents, in the main, the trial of the Louisville Leavitt Pumping Engine as described in the "Transactions of the American Society of Mechanical Engineers," Vol. XVI, and the data are sufficiently full to enable the flow of heat to be stated at all points with fair accuracy. The numerals represent British thermal units flowing per minute; the streams are drawn to such a scale that each inch of width represents a flow of 100,000 B.T.U. per minute. Temperatures are also given.

Starting at the fire grate, it is shown that 183,600 B.T.U. are produced per minute by the combustion of the coal, and that 131,700 of these go direct into the water of the boiler, 10,000 are lost by boiler radiation and leakage, and the remainder, viz: 41,900, pass away with the flue gases. On the way to the economizer, 1,000 B.T.U. are lost by radiation, but in the economizer itself 15,750 B.T.U. are diverted into the feed water, 5,000 B.T.U. are dissipated by radiation, and finally 20,150 B.T.U. pass out of the economizer and into the chimney, and are lost to the steam plant. The heat entering the economizer with the feed water is 5,450 B.T.U., which is added to the 15,750 B.T.U. diverted from the flue gases, thus giving a flow of 21,200 B.T.U. in the feed out of the economizer. Radiation, however, reduces this flow to 20,950 B.T.U. per minute at the entry to the boiler, where a further addition is made of 6,600 B.T.U. returned by the jacket water.

The steam produced by the boiler is thus seen to derive its heat from three streams, as shown on the diagram; the steam finally leaves the boiler with 159,250 B.T.U. per minute. Before this heat gets to the engine, however, 3,100 B.T.U. are lost by radiation and leakage from the steam pipes, so that the flow of heat is reduced to 156,150 B.T.U. per minute, which is the gross supply of heat to the engine; the net supply is less, because there are certain returns of heat to the boiler to be deducted. In the first place, credit has to be given to the engine for the heat which could be imparted by means of the exhaust steam to the feed

water, inasmuch as the exhaust is theoretically, and very nearly practically, capable of raising the temperature of the feed to the exhaust temperature. On this basis, 7,400 B.T.U. should be credited to the engine, although the actual return to the boiler, or rather to the economizer, is only 5,450 B.T.U. The difference is due to excess of circulating water, which lowers the hot-well temperature, and also to radiation in the feed arrangements, which are a necessary portion of the steam plant, independent of the engine proper, and which are not applied to correct any fault of the engine. The loss of 1,950 B.T.U. should, therefore, be debited to the feed and condensing arrangements, and not to the engine. It will be seen that the 7,400 B.T.U. credited to the engine is equal to the water heat of the feed at the temperature of the exhaust, which is in agreement with the rule given at page 956 for calculating the "heat supplied to the engine," and also with the third recommendation of the committee. In the present case a special credit has to be given to the engine, because 6,750 B.T.U. leave the engine in the jacket water to return to the boiler; but 150 are lost by radiation on the way, so that the net return is 6,600 B.T.U. Only the net return to the boiler should be credited to the engine, because the jackets are applied to correct a fault of the engine, namely, cylinder condensation; hence, any loss to the steam plant that may be entailed by the use of jackets (*i. e.*, the radiation in question) should be reckoned as a loss due to the engine, although it takes place outside the engine. In the case under consideration the jacket water was returned direct to the boiler, but if, as is frequently the case, the jacket water is drained into the hot well, the heat in it can not be credited to the engine, for the reasons given above.

The net supply to the engine can, therefore, be obtained as follows:

	B.T.U.	B.T.U.
Gross supply	...	156,150
Less returnable by feed	7,400	
Less returned by jackets	6,600	
		14,000
Net supply per minute		142,150

On referring to the plate it will be seen that only 27,260 B.T.U. are utilized as work upon the pistons. The ratio of the heat so utilized to the net heat supplied is called in the report the "thermal efficiency of the engine," and it is to be observed that this is the usual meaning applied to this term, although some writers, notably Mr. Willans, applied the term to another ratio, as mentioned on page 955. In the numerical case under consideration the thermal efficiency is $\frac{27,260}{142,150} = 0.19$.

The engine under discussion indicates 643 H.P.; the heat supplied "per minute per I.H.P." is, therefore, $\frac{142,150}{643} = 221$ B.T.U., and it is this figure which, as recommended in the report, should be used to express the thermal economical value of a steam engine. This recommendation is made with a view of replacing the present usual method of stating the performance in pounds of feed water per I.H.P. per hour, although the latter statement is useful for other purposes.

It will be seen that 1,870 B.T.U. are deducted from the 27,260 utilized as work on the pistons, as engine friction, so that the effective or brake power of the engine corresponds to 25,390 B.T.U. per minute; in other words, the brake H.P. of the engine is 599 —so that the "B.T.U. per minute per B.H.P." are $\frac{142,150}{599} = 237$ —another figure which the committee recommends should be quoted whenever it is possible to ascertain the brake efficiency.

Let it now be supposed that the actual steam engine is replaced by an ideal steam engine, forming part of an idealized steam plant working according to the "Rankine cycle," using for this cycle the name recommended by the committee. It must be assumed that the I.H.P. of the "ideal" engine is the same as that of the "actual" engine, namely, 643 H.P., and that the admission and exhaust temperature are the same, namely, 359 degrees Fahrenheit and 100 degrees Fahrenheit respectively. The flow of heat in the ideal steam plant is represented by the lower diagram in the plate, and it will be observed that all the losses have disappeared, except the flue loss and the heat carried away

by the condensing water. There are no jackets, but there is an economizer, because, although the boiler is perfect, 31,400 B.T.U. are sent into the flue, since the gases can not be cooled down below the temperature of the water in the boiler, and a portion of this heat can be saved by heating the feed to the steam temperature. The heat returnable by the feed is, of course, less than in the case of the actual engine, owing to the reduced weight of steam passing through the engine. The heat supplied to the ideal engine is, therefore:

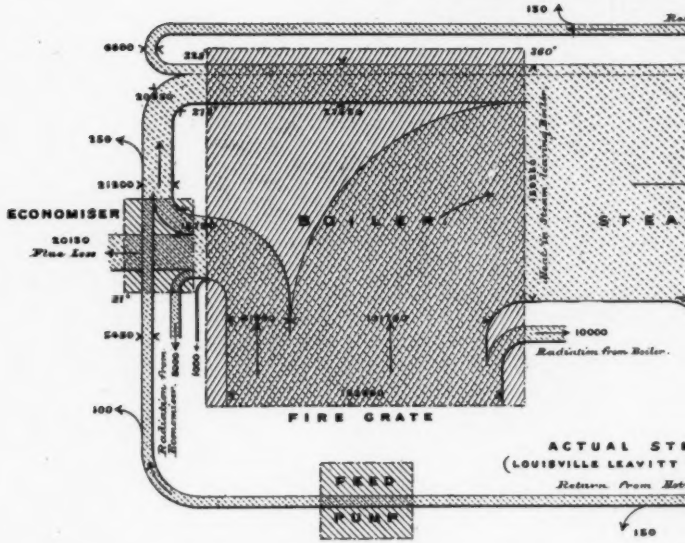
	B.T.U.
Gross supply	100,900
Less returned by feed	5,600
Net heat supplied per minute	95,300

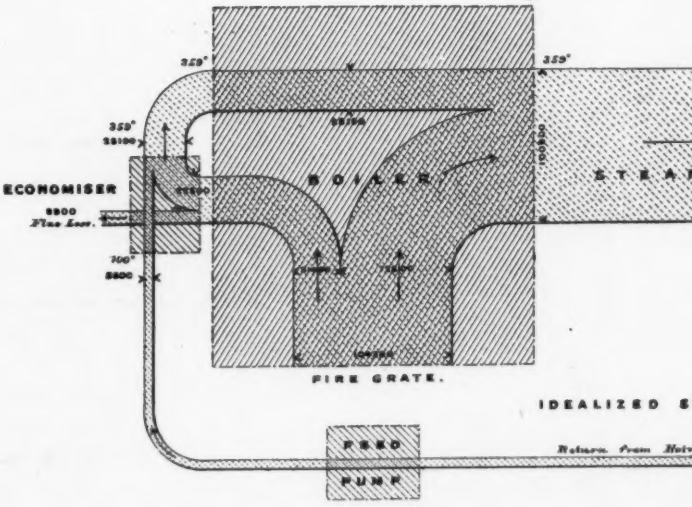
The I.H.P. of the ideal steam engine being the same as that of the actual engine, the same number of B.T.U. per minute are utilized as work upon the pistons, namely, 27,260. The thermal efficiency of this ideal steam engine is, therefore, $\frac{27,260}{95,300} = 0.285$, and the B.T.U. per minute per I.H.P. are $\frac{95,300}{643} = 148$, as against 221 for the actual engine. The actual engine, therefore, requires 73 B.T.U. per minute per I.H.P. more than the ideal engine; these heat units are lost on account of imperfections in the actual engine, and can be looked upon as a measure of these imperfections. The ideal steam engine thus becomes the "standard of comparison," as recommended and defined by the committee.

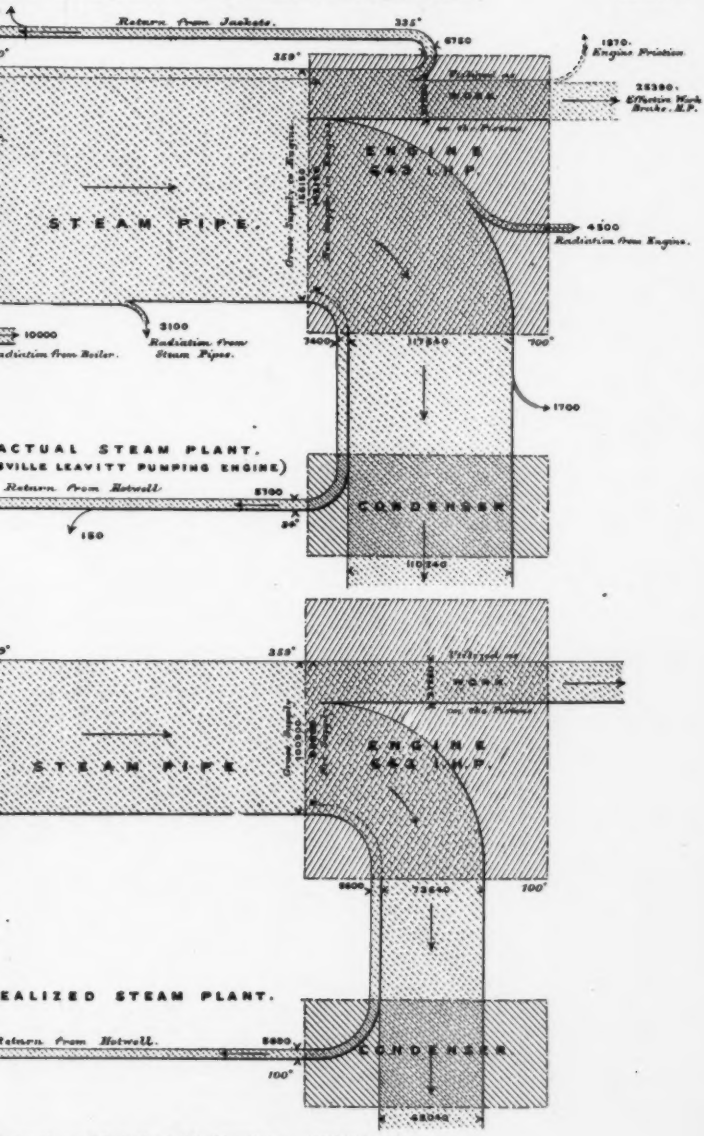
The number of B.T.U. per minute per I.H.P. required by the ideal engine depends on the temperature of the steam at admission and its temperature at exhaust, and also on whether the steam is saturated or superheated. Figs 3 and 3*a* in the report have been drawn to enable this number of B.T.U.'s or of calories to be read off directly in all cases likely to occur in practice.

If the number of B.T.U. per minute per I.H.P. required by the ideal engine be divided by the number needed by the actual engine, there is obtained what has been called the "efficiency ratio" by the committee. In the numerical case under consideration this ratio is $\frac{148}{221} = 0.67$.

THE THERMAL EFFICIENC






Return from Jackets.
335°
6750
359°
1370.
Engine Friction
Effective Work.
Brake H.P.
25380.
WORK.
ENGINE
443 I.H.P.
STEAM PIPE.
4500
Radiation from Engine.
10000
3100
Radiation from Steam Pipes.
7400
700°
1700
ACTUAL STEAM PLANT.
BVILLE LEAVITT PUMPING ENGINE)
Return from Hotwell
5100
150
CONDENSER
359°
WORK.
ENGINE
443 I.H.P.
STEAM PIPE
9400
700°
EALIZED STEAM PLANT.
Return from Hotwell.
5800
100°
CONDENSER

In order to connect this term with recent writings on the steam engine, it should be stated that Mr. Willans called this ratio the "thermal efficiency;" he, however, employed exactly the same standard of comparison as that now recommended by the committee. Professor Osborne Reynolds has called this ratio "the percentage of theoretical efficiency," but his standard of comparison was different. Captain Sankey has called this ratio the "standard thermal efficiency," and has also suggested a somewhat different standard of comparison.

In conclusion, the result of the committee's work can shortly be said to consist in the recommendation that the thermal economical value of steam engines should be stated in B.T.U. per I.H.P. per minute; in defining the standard engine of comparison; and in giving precise directions for the observations to be taken, and for the calculations to be made, in regard to the foregoing.

Report of the Committee.

On the 12th April, 1897, your committee submitted a preliminary report which embodied the gist of the conclusions they had arrived at. * * *

Your committee have now the honor to forward their final report.

There are two methods of stating the thermal economical value of a steam engine.* In the first, which is principally used for scientific purposes, it is expressed as a ratio, and it is in this connection that a so-called "standard" of thermal efficiency is needed; in the second and more ordinary method, an absolute statement is used, such as pounds of feed water per I.H.P., or heating units supplied per I.H.P. per unit of time.

THERMAL ECONOMICAL VALUE EXPRESSED AS A RATIO.

There are several such ratios relating to quite distinct orders of ideas, and the term "thermal efficiency" has been indiscrimi-

* For the purposes of this inquiry a steam engine will be taken to include everything between the boiler side of the engine stop valve and the exhaust flange, so that neither the boiler, the feed arrangements, nor the condenser, if there be one, are taken into consideration.

nately used for all of them. For instance, the term has been applied by some authors to the ratio which the work done upon the pistons of the engine, and shown by the indicator, bears to the heat supplied to the engine; by others to the ratio of the performance of the engine, as above defined, to that of some ideal engine; and by others even to some quantity not a ratio at all, although more or less representing an economical result.

With the view of avoiding risk of misunderstanding in future, and of obtaining the great advantage which would result from the adoption of a uniform system of nomenclature, your committee submit and recommend for use the following definitions:

The expression, "thermal efficiency," as applied to any heat engine, should mean the ratio between the heat utilized by that engine and the heat supplied to it, or

$$\text{thermal efficiency} = \frac{\text{heat utilized as work on the pistons}}{\text{heat supplied to the engine}}.$$

In the case of any particular actual steam engine this ratio can be determined by calculations based on actual experiment in the following manner:

The heat units utilized as work are to be obtained by measuring the indicator diagrams of the engine in the usual way to ascertain the mechanical work done.

The heat supplied to the engine is to be calculated as the heat required to produce at constant pressure the steam that enters the engine, from water at the temperature of the engine exhaust.* This rule applies whether the steam be saturated or superheated; also whether the engine be non-condensing or condensing.†

In the case of an ideal engine working between certain tem-

* The above is equivalent to the following statement: The heat supplied to the engine per minute is equal to the total heat of the steam entering the engine less the water heat at the temperature of the engine exhaust of the same weight of water. The temperature of the engine exhaust is taken because, theoretically, the feed can be raised by the exhaust to this temperature, although the result is not usually realized in practice.

† Special cases occur when steam is abstracted from the engine before final exhaust to heat the feed or when the steam is "reheated" in the receivers. Subtraction or additions to the heat units supplied must then be made.

peratures according to some theoretical cycle, the term "thermal efficiency" will equally represent the ratio of heat utilized to heat supplied.

For many important purposes it is required to know both the thermal efficiency of a particular engine and the calculate thermal efficiency of some ideal engine more or less closely corresponding to it. The ratio between these two efficiencies is a matter of special importance. This ratio between two efficiencies has often been itself called an efficiency, but your committee think that this use of the word has led to no little confusion, and consider it undesirable.

The ideal steam engines thus contemplated are the "standards of thermal efficiency" which form the subject of the reference to your committee; but, as in the opinion of your committee the use of the words "thermal efficiency" is undesirable in this connection, they recommend that such an ideal steam engine be called the "standard steam engine of comparison," and that the ratio of the thermal efficiency of any actual steam engine to the corresponding standard steam engine of comparison be called the "efficiency ratio."

It will be seen from the foregoing that two ratios are required to fully express the thermal economical value of a steam engine, namely, the thermal efficiency, which gives the proportion of the heat utilized as work upon the pistons to the heat supplied, and the efficiency ratio, which is the measure of the extent to which the actual engine fails to reach the physical possibilities of the conditions under which it is working.

The next step is to decide what the standard steam engine of comparison should be.

STANDARD STEAM ENGINE OF COMPARISON.

As is well known, a heat engine working on the Carnot cycle would give the maximum utilization of the heat supply; but it is impossible for a steam engine to work on this cycle when the working substance is saturated steam, unless it be provided with a dynamical feed heater, an arrangement probably outside any future developement of the steam engine. For an engine using

superheated steam produced at constant pressure, the Carnot cycle is thoretically impossible, even with a dynamical feed-heater.

An ideal steam engine working on the cycle defined by Rankine, Clausius and others * gives the maximum utilization of the heat supply when the working substance is steam, either saturated or superheated, when produced at constant pressure, and is to be regarded as the perfect steam engine. In this connection it is to be observed that every working substance has its own cycle of maximum utilization of the heat supply, depending on the method in which heat is applied to it.

Actual steam engines fall far short of the perfect steam engine, owing principally to incomplete expansion, to the use of conducting materials for cylinders, and to the clearances that have to be observed for mechanical and other reasons. Ideal cycles can be devised to take account of these practical necessities for each particular type of engine, but if such a cycle were devised for general use, arbitrary limitations would be required, which your committee do not see their way to recommend.

For saturated steam, within the temperature limits at present in use, the difference between the thermal efficiency of the Carnot cycle and of the Rankine cycle is inconsiderable. For instance, if the higher temperature limit is 370 degrees Fahrenheit and the lower temperature limit is 110 degrees Fahrenheit, the thermal efficiency of the Carnot cycle is 0.313 and the thermal efficiency of the Rankine cycle is 0.283. If the lower limit of temperature be increased to 212 degrees Fahrenheit (in a non-condensing engine) the thermal efficiency of the two cycles is still closer, viz: 0.19 and 0.178. In view of the fact that the efficiency ratio rarely reaches 0.7 in the case of a condensing engine, or 0.8 with a non-condensing engine, there would seem to be little practical objection to using the Carnot cycle instead of the Rankine, while there would be advantage in the former in simplicity of calculation.

* This ideal steam engine has often been called the Clausius engine, but Rankine was the first to describe its cycle. Your committee therefore prefer to call this cycle the Rankine cycle, and it is defined on page 959.

For superheated steam, however, there is a much greater difference between the thermal efficiencies of the two cycles. For instance, if the pressure is 185 pounds per square inch absolute, and the admission temperature of the steam 650 degrees Fahrenheit, and the lower limit of temperature is 100 degrees Fahrenheit, it will be found that the thermal efficiency of the Carnot cycle 0.495, while the thermal efficiency of the Rankine cycle is only 0.31. Comparison with the Carnot engine might in this case give rise to undue expectations as to the possibilities of superheated steam.*

After careful consideration, your committee recommend an ideal steam engine working as part of the Rankine cycle as the standard steam engine of comparison, both for saturated and for superheated steam engines.

The definition of the Rankine cycle is as follows: It is assumed that all the component parts of the steam plant are perfect, and that there are no losses due to initial condensation, leakage, radiation or conduction, and that there is no clearance in the cylinder. The feed water required is taken into the boiler at the exhaust temperature, and its temperature is gradually raised until that corresponding to saturated steam is reached. Steam is then formed at constant pressure until dry saturated steam is produced, after which, if the steam is to be superheated, heat is added at constant pressure and at increasing temperature, until the required temperature of superheat is reached. The steam is intro-

* The following numerical example also throws some light on this point. Suppose that an engine working with superheated steam of 120 pounds per square inch absolute pressure and 300 degrees Fahrenheit superheat at admission is stated to require 7.6 pounds of feed water per I.H.P. per hour. The temperature of the exhaust is 120 degrees Fahrenheit. Can the statement be true? On calculation it is found that the thermal efficiency of the engine is $\frac{42.4 \times 60}{1,242 \times 7.6} = 0.27$. The thermal efficiency of the Carnot cycle for the limiting temperatures of 641 degrees Fahrenheit and 120 degrees Fahrenheit is 0.473, so that the actual engine only performs 57 per cent. of what the corresponding Carnot cycle engine could do. But the thermal efficiency of the Rankine cycle for this superheated steam is 0.268, so that the actual engine is claimed to do over 100 per cent. of what the Rankine cycle engine could do, or, in other words, does more than is physically possible. Clearly the Carnot cycle helps little in discovering a misstatement of this kind, whilst the Rankine cycle exposes it at once.

duced into the cylinder at constant pressure, displacing the piston, and performing external work equal to the absolute pressure multiplied by the volume swept through by the piston up to the point of cut-off. Beyond that point expansion takes place adiabatically, doing work until the pressure in the cylinder is equal to the back pressure against which the engine is working. The steam is then completely exhausted from the cylinder at constant pressure corresponding with the lower limit of temperature, work being done on the steam by the engine during exhaust, equal to the absolute back pressure multiplied by the total volume swept through by the piston. The steam is thus removed from the cylinder and the cycle is complete.

To calculate the heat supply in any particular case, the only data required are the higher and lower limits of temperature, and for superheated steam the admission pressure as well.

Higher Limit of Temperature (t_a) *and of Pressure.*—In the ideal Rankine cycle engine just described, the temperature and pressure are the same in the cylinder at cut-off as in the boiler or superheater; but in an actual engine, the temperature and pressure are always less in the cylinder than in the boiler. There are five different places at which the measurements can be taken:

(1) The boiler.
(2) The stop valve.
(3) The valve chest.
(4) The cylinder during admission.
(5) The point of cut-off.

The temperature and pressure of steam in the boiler, owing to the losses in the connecting steam pipes, are of necessity higher than at the stop valve of the engine, and it would be unfair to the engine to reckon these losses against it. Moreover, cases may arise where the steam is superheated in a separately-fired superheater close to the engine. It is, therefore, undesirable to measure the upper limit of temperature and pressure at the boiler.

On the other hand, to take the temperature and pressure in the cylinder during admission, and still more to take them at the point of cut-off, would favor the engine by ignoring some of its defects.

Taking the temperature and pressure at the valve chest also favors the engine. In many cases there are considerable variations of pressure in the valve chest during the stroke, as was shown by experiments undertaken for the purpose and described in Appendix II.

Your committee, therefore, recommend that the upper limit of pressure and temperature be taken close to, but on the boiler side of, the stop valve.

Lower Limit of Temperature (T_o).—It has been less easy to come to a conclusion as to the lower limit of temperature, many views having been expressed on this subject, for the most part tending to fix the limit, either in accordance with the conditions affecting the exhaust of the actual engine, or at some constant but arbitrary value.

Experiments were made to ascertain the degree of accuracy with which the temperature of the steam in the exhaust of an engine could be measured. These are described in Appendix IV, and the conclusion drawn from them is that this temperature can be obtained with sufficient accuracy, either directly by a thermometer placed in the exhaust pipe, or indirectly by observing the pressure in the exhaust pipe and taking the corresponding steam temperature, provided a vacuum gage of the mercurial barometric type, or an indicator, be used to measure this pressure.

After a considerable amount of discussion, your committee decided to recommend that the lower limit of temperature should be measured in the exhaust pipe outside, but close to, the engine.

This recommendation covers the special cases of an engine working against a high back pressure, and of an engine working, at a considerable terrestrial elevation, in an atmosphere of low barometric pressure.

THERMAL ECONOMICAL VALUE EXPRESSED IN HEAT UNITS.

Referring to page 955, the thermal economy expressed in heat units has now to be considered. It has been frequently pointed out, even as far back as 1881 by Mr. Mair-Rumley, that the usual method of expressing the thermal economy of a steam engine in

pounds of feed water per hour is inaccurate, because the number of heat units required to produce a pound of steam depends upon the circumstances of its production. The error is unimportant so long as we are dealing with saturated steam, but when using superheated steam the error may be as much as 10 per cent. or even 15 per cent., and cannot therefore be neglected.

If the heat supplied to an engine per minute, as calculated by the rule given on page 956, is divided by the I.H.P., we obtain a number which is a true measure of the thermal economy of the engine, namely, the number of British thermal heat units supplied per minute per I.H.P., and a similar number can be obtained per B.H.P. Further, the B.T.U. required per I.H.P. by the standard steam engine of comparison can also be calculated, if the limiting conditions are given.

The complete statement can be tabulated as follows, two numerical examples being added by way of illustration :—

DATA.

	Numerical examples.	
(1) Stop-valve pressure (absolute) pounds per square inch.....	158	185
(2) Stop-valve temperature, degrees Fahrenheit.....	362	650
(3) Exhaust temperature, degrees Fahrenheit.....	213	100
(4) I.H.P.....	500	1,300
(5) B.H.P.....	450	1,155
(6) Weight of steam entering engine per minute, pounds.....	171	222

RESULTS.

Actual engine:		
(7) B.T.U. supplied per minute per I.H.P.....	345	215
(8) B.T.U. supplied per minute per B.H.P.....	385	242
Standard engine of comparison:		
(9) B.T.U. theoretically required per minute per I.H.P.....	250	136
(10) Efficiency ratio.....	0.725	0.633

The "B.T.U. supplied per minute per I.H.P.," together with the "B.T.U. supplied per minute per B.H.P.," give all the information as regards economy needed by the user, and correspond with the "feed water per I.H.P." and "per B.H.P." at present in use. The addition of the B.T.U. per minute required by the standard engine of comparison gives the further information needed for scientific purposes.

It will be seen that the number of B.T.U. lost by imperfections in the actual engine can be obtained by the subtraction of line 9 from line 7, which is a valuable and suggestive piece of information.

The estimation of the B.T.U. supplied per I.H.P. from the usual observations made at trials is easy. For instance, suppose the following observations are made with an engine using saturated steam :—

I.H.P.	520
Weight of steam entering engine per minute, pounds	108.3
Stop-valve pressure, pounds per square inch, absolute	170
Exhaust pressure, pounds per square inch, absolute	2

The heat supplied per pound of feed, as defined on page 956, is $1{,}194 - 94 = 1{,}100$ B.T.U. Hence the B.T.U. per minute per I.H.P. $= \frac{108.3 \times 1{,}100}{520} = 229.$

The B.T.U. per H.P. for the standard engine of comparison can be calculated as follows :—

The formula* for the thermal efficiency of the Rankine cycle for saturated steam is

$$\frac{\left(T_a - T_e\right)\left(1 + \frac{L_a}{T_a}\right) - T_e \text{ hyp log } \frac{T_a}{T_e}}{L_a + T_a - T_e},$$

in which formula the increase in the specific heat of water at higher temperatures affects the numerator and denominator nearly equally.

The B.T.U. per minute per H.P. for the standard engine of comparison is 42.4 divided by the thermal efficiency of the Rankine cycle thus :—

For saturated steam, the B.T.U. per minute per H.P. for the standard engine of comparison is :—

---

* Meaning of the letters used in the following formulas :—

T_a absolute temperature of saturated steam at stop-valve pressure.

T_{as} absolute temperature of superheated steam at stop-valve.

T_e absolute temperature in exhaust.

L_a latent heat of steam at temperature T_a.

$$\frac{42.4\,(L_a + T_a - T_e)}{\left(T_a - T_e\right)\left(1 + \frac{L_a}{T_a}\right) - T_e \text{ hyp log } \frac{T_a}{T_e}},$$

and similarly for superheated steam it is:—

$$\frac{42.4\,\{L_a + T_a - T_e + 0.48\,(T_{as} - T_a)\}}{\left(T_a - T_e\right)\left(1 + \frac{L_a}{T_a}\right) + 0.48\left(T_{as} - T_a\right) - T_e\left(\text{hyp log } \frac{T_a}{T_e} + 0.48 \text{ hyp log } \frac{T_{as}}{T_a}\right)}.$$

It will be noticed that the usually accepted figure of 0.48 for the specific heat of superheated steam at constant pressure has been taken, although this figure is open to much doubt.

These formulas being somewhat complex, the curves shown in Fig. 3 have been prepared, from which the B.T.U. per minute per H.P. in the case of saturated steam can be read off directly.*

In the case of superheated steam, the figure is obtained by applying a correction to that got for saturated steam. At the bottom of Fig. 3 is a set of curves marked "coefficient for superheat correction." Against the temperature of saturation corresponding to the stop-valve pressure, and on the curve corresponding to the temperature of the superheated steam (T_{as}), is found a coefficient. This coefficient multiplied by the exhaust temperature, and by the B.T.U. already found, gives the deduction to be made from these B.T.U.†

Further numerical examples are given in Appendix III.

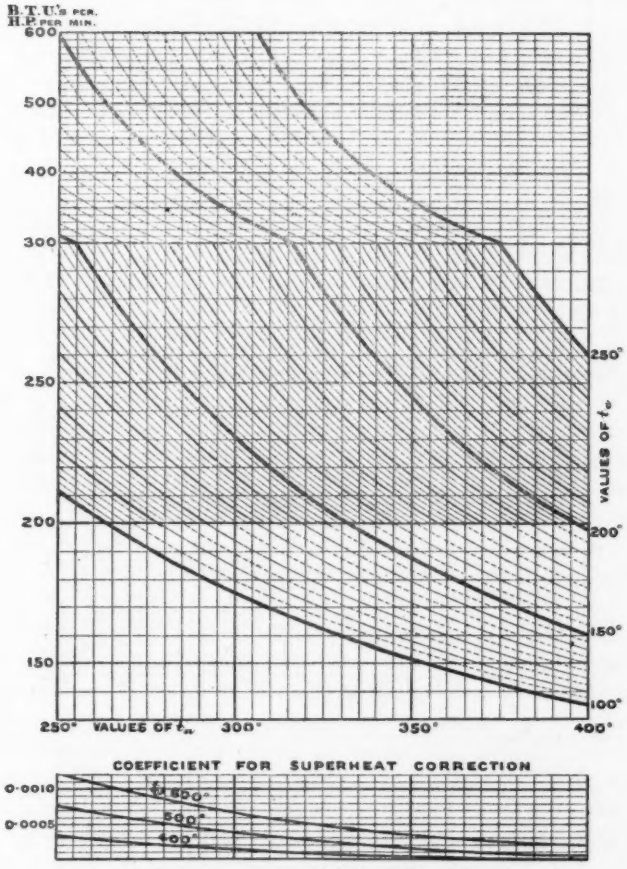
It is further to be observed that this method of statement is applicable to all heat engines whether using steam, gas, oil or air. Calculations in respect of fuel consumption are more readily made than when the feed per I.H.P. is given, as will be seen on referring to Appendix V.

RELATION BETWEEN THERMAL ECONOMY EXPRESSED IN HEAT UNITS AND AS A RATIO.

The thermal efficiency, as defined on page 956, is proportional to the inverse of the B.T.U. required per minute per I.H.P., and

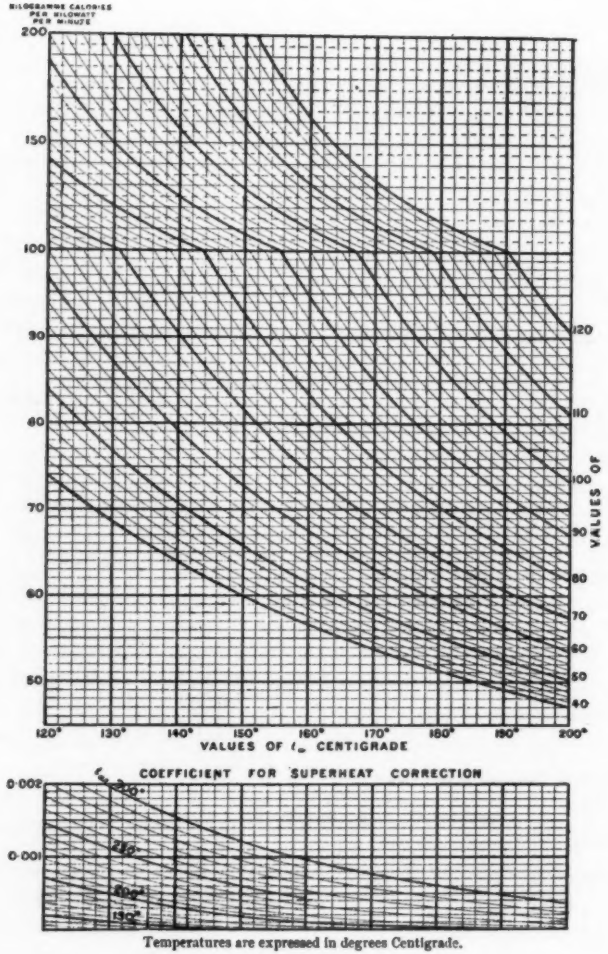
* Thus for $T_a = 350$ degrees and $T_e = 212$ degrees, the figure is 265.

† Thus, let $T_{as} = 500$ degrees, $P_a = 135$ pounds (so that $T_a = 350$ degrees), and $T_e = 212$ degrees. Against 350 degrees, and on the curve for 500 degrees, we read the coefficient 0.00015. This gives the correction thus: $0.00015 \times 212 \times 265 = 8.5$, and $265 - 8.5 = 256.5$, the number of B.T.U.'s required.



Temperatures are expressed in degrees Fahrenheit.

FIG. 3.



Temperatures are expressed in degrees Centigrade.

FIG. 3*a*.

if we divide the energy of 1 H.P. per minute expressed in thermal units, namely 42.4, by the B.T.U. required per I.H.P. per minute, we obtain the thermal efficiency.*

The efficiency ratio, as defined on page 956, is equal to the B.T.U. theoretically required per I.H.P. per minute by the standard engine of comparison divided by the B.T.U. supplied per minute per I.H.P. to the actual engine.†

RECOMMENDATIONS BY THE COMMITTEE.

Having considered the various questions connected with the subject as detailed in the report, your committee recommend:

1. That "thermal efficiency" as applied to any heat engine should mean the ratio between the heat utilized as work on the piston by that engine and the heat supplied to it.

2. That the heat utilized be obtained by measuring the indicator diagrams in the usual way.

3. That in the case of a steam engine, the heat supplied be calculated as the total heat of the steam entering the engine less the water heat of the same weight of water at the temperature of the engine exhaust, both quantities being reckoned from 32 degrees Fahrenheit.

4. That the temperature and pressure limits, both for saturated and superheated steam, be as follows:

Upper limit: the temperature and pressure close to, but on the boiler side of, the engine stop valve, except for the purpose of calculating the standard of comparison in cases when the stop valve is purposely used for reducing the pressure. In such cases the temperature of the steam at the reduced pressure shall be substituted. In the case of saturated steam the temperature corresponding to the pressure can be taken.

Lower limit: the temperature in the exhaust pipe close to, but outside, the engine. The temperature corresponding to the pressure of the exhaust steam can be taken.

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*Thus in the first numerical example, page 962, the thermal efficiency is $\frac{42.4}{345}=0.123$.

† In the numerical example for saturated steam, page 291, this efficiency ratio is $\frac{250}{345}=0.725$, and in the example for superheated steam it is $\frac{136}{215}=0.633$.

5. That a standard steam engine of comparison be adopted, and that it be the ideal steam engine working on the Rankine cycle between the same temperature and pressure limits as the actual engine to be compared.

6. That the ratio between the thermal efficiency of an actual engine and the thermal efficiency of the corresponding standard steam engine of comparison be called the efficiency ratio.

7. That it is desirable to state the thermal economy of a steam engine in terms of the thermal units required per minute per I.H.P., and that, when possible, the thermal units required per minute per B.H.P. be also stated.

8. That, for scientific purposes, there be also stated the thermal units required per minute per H.P. by the standard engine of comparison, which can readily be obtained from a diagram similar to that given in Fig. 3, and from which the efficiency ratio can be deduced.

Your committee would also suggest that in papers submitted to the Institution bearing on steam-engine economy, authors be invited to conform to the above recommendations.

Appendix III.

FOURTEEN EXAMPLES OF STEAM ENGINES WORKING UNDER VARYING CONDITIONS.

Referring to page 290, the accompanying Table gives an abstract of the working out of some examples of steam engines working under various conditions. The following points are worth noticing:

Examples 1 and 2.—Comparing examples 1 and 2, it will be seen that according to column IV both these engines are doing about 56 per cent. of the theoretical possibility, due to their environment, that is, they both have an efficiency ratio of 0.56. The thermal efficiency of the first example is only 0.12, and in the second it is as much as 0.17. The improvement in work return is due to the higher boiler pressure and better vacuum. If, however, these two examples are compared by the figures given in column 1 it would appear that the *Iona's* engine is

making better use of its opportunities in the proportion of 58 to 41. The former comparison, viz: 56, is surely the more accurate; but it must not be argued from this that if the *Ville de Douvres* engines were put to work with 167 pounds stop-valve pressure and 0.7 pound per square inch exhaust pressure, that they would still have an efficiency ratio of 0.56. It will, of course, be a less ratio, inasmuch, as the engines would not then be suitably designed for the new conditions.

Examples 4 and 7.—These examples show that the engine was in each case arranged so as to make the same use of its opportunities, namely, 0.74 and 0.73 efficiency ratio, which is reasonable, seeing that the cut-off had been adjusted by Mr. Willans in each case to give the best results. The thermal efficiency in the first case is, however, greater, owing to the better conditions under which the engine of example 4 is working.

Examples 2 and 6.—The thermal efficiency is greater in example 6 than in example 2, because the engine makes better use of its opportunities, which are not quite so good in example 6 as they are in example 2, owing to the exhaust being at a higher pressure. This example 6, together with example 2, illustrates also the disadvantage of taking the temperature of injection as the lower temperature. If this temperature had been chosen, the efficiency ratio for example 2 would have been 0.51, and 0.50 for example 6, which would have made it appear that engine 6 is not quite so good as engine 2, whereas in reality it is better.

Examples 7, 8 and 9 have very nearly the same thermal efficiency, notwithstanding the varying conditions as regards back pressure; the efficiency ratio gives the reason. This particular engine had been designed to give the best results when non-condensing, and its efficiency ratio under these circumstances is 0.73 (columns III and IV). It was then put on the condenser without any change, not even of cut-off, and being then unsuited to its environment gave only 0.66 with a bad vacuum, and only 0.51 with a moderate vacuum. If, in this latter case, without changing the design of the engine in any way, but merely altering the

Data abstracted from table issued to the members of the committee on the 23d December, 1896.

A.	B.	C.	F.	J.	K.	N.	Thermal efficiency.	Efficiency ratios.				Proposed method of comparison in B.T.U.		
								Fixed lower limit of temperature.*		Lower limit of temperature varying with conditions of running.*				
Case.	Engine.	Reference and authority.	Temperature of steam at stop valve.	Temperature of steam in exhaust pipe just outside engine.	Temperature in hot well.	Pounds of feed water per I.H.P. per hour.		I. Non-condensing, 212° F. Condensing, 100° F.	II. All steam engines 100° F.	III. Hot-well temperature (col. K).	IV. Temperature in exhaust just outside engine (col. J).	B.T.U. per I.H.P. per minute.	B.T.U. per B.H.P. per minute.	B.T.U. per H.P. per minute for standard engine of comparison.
			° F.	° F.	° F.									
1	S. S. *Ville de Douvres*	Dr. Kennedy, Proc. Inst. Mech. E.; Prof. Hudson Beare's Report	(338)	160	160	20.8	0.12	0.41	0.41	0.56	0.56	367	...	205
2	S. S. *Iona*	do.	(367)	91	75	13.4	0.17	0.58	0.58	0.52	0.56	254	...	141
3	Willans (experimental engine)	Willans non-condensing trials; Min. Proc. Inst. C. E., vol. xciii $C\frac{80}{3.2}$	(322)	213	...	26.2	0.10	0.72	0.34	...	0.74	436	506	321
4	do.	$C\frac{160}{6}$	(370)	212	...	19.2	0.13	0.73	0.40	...	0.74	325	356	239
5	do.	Willans, condensing trials; Excerpt Min. Proc. Inst. C. E., vol. cxiv $\frac{T75}{20.6}$	(312)	91	(70)	15.3	0.15	0.60	0.60	0.51	0.57	285	458	162
6	do.	$\frac{T175}{12.36}$	(375)	105	(70)	12.7	0.18	0.60	0.60	0.53	0.61	238	268	145
7	Willans II-S engine, driving "Holmes" dynamo	Dr. Kennedy, tests made at Thames Ditton on the 20th May, 1893	(362)	213	...	20.5	0.12	0.72	0.38	...	0.73	345	383	250
8	do.	do.	(362)	193	(190)	(19.6)	0.13	0.40	0.40	0.65	0.66	337	374	220
9	do.	do.	(362)	135	(130)	18.2	0.13	0.43	0.43	0.50	0.51	330	367	168
10	"Milwaukee" pumping engine	Thurston, Trans. Am. Soc. Mech. Eng., vol. xv	350	126	105	11.7	0.20	0.69	0.69	0.71	0.79	213	235	168
11	do. H.P.C.	do.	350	277	...	38.4	0.07	(0.41)	(0.21)	...	0.80	603	...	481
12	do. I.P.C.	do.	277	216	...	39.7	0.06	(0.76)	(0.26)	...	0.81	649	...	527
13	do. L.P.C.	do.	216	126	105	29.3	0.08	(0.62)	(0.62)	0.52	0.64	515	...	328
14	Imaginary steam engine	.....	338	162	160	13.0	0.19	0.64	0.64	0.90	0.91	228	...	208

* In all cases the stop-valve temperature was chosen as the higher limit of temperature. Various values were chosen for the lower limit of temperature.

proportion of the cylinders and the cut-off, the efficiency ratio when condensing would have risen to about 0.65.

Example 8.—In this example, if treated as a condensing engine with 100 degrees Fahrenheit for the lower limit of the standard engine of comparison, the efficiency ratio (column I or II) comes out at only 0.40; but when the vacuum improves, and the engine is still less suited to its environment, example 9, a better efficiency ratio of 0.43 is obtained. This is, obviously, not a helpful comparison.

Example 10 gives the results of one of the best trials on record, and it is interesting to note that even this engine is only able to do 79 per cent. of the possibilities. This may be looked upon as the high-water mark of present engine economy with saturated steam.

Examples 11 and 12 show that the H.P. and the intermediate cylinders of this engine are making rather better use of their opportunities than the L.P. cylinder. A considerable portion of the loss of the L.P. cylinder is of course due to the necessary cutting off of the toe of the diagram in this cylinder.

Example 14.—The efficiency ratio in columns III and IV is given as 0.90 and 0.91. This efficiency ratio is so high that it ought to excite suspicion as to the accuracy of the test. The thermal efficiency is 0.19, which, although high, is not so good as that in example 10. In columns I and II the efficiency ratio (with fixed lower limits of temperature of 100 degrees Fahrenheit) is only 0.64, and this figure would not call attention to there being anything wrong with the test. If the matter is inquired into a little further, however, and the engine is compared with one working on an ideal cycle, having for its lower temperature limit the temperature of the exhaust in the L.P. cylinder, and with the toe cut off at 2 pounds above the exhaust, it will be found that the efficiency ratio is no less than 0.96 or 0.97; that is to say, this engine would be actually doing within 3 per cent. of the real theoretical possibility. In other words, it is practically an impossible engine. One object of the efficiency ratio is to detect error. This it does, as is seen above, if the lower limit of temperature is taken as that in the exhaust, but it fails to do so if a fixed lower limit of temperature of 100 degrees Fahrenheit is

Various values were chosen for the lower limit of temperature. ... the stop-valve temperature was chosen as the higher limit of temperature.

taken. It is further interesting to note that, according to column I, engine 14 is not so good as engine 10, whereas in reality it is so much better that it is impossible.

Cases will occur in which it is of scientific interest to determine the efficiency ratio of any particular cylinder of a compound or of a triple-expansion engine. This can be readily done if the temperatures are taken as in column IV (see examples 11, 12 and 13), but obviously absurd results are obtained if a fixed lower temperature is taken, as in columns I and II.

Appendix IV.

Experiments were made by Prof. Beare and Capt. Sankey to determine the degree of accuracy with which the lower limit of

TABLE OF LOWER LIMITS OF TEMPERATURE.

Trial.	Speed of engine.	Vacuum. Mean gage readings.		Temperature in degrees Fahrenheit.		
				Corresponding to pressure shown by—		Mean readings of mercurial thermometer.
		Mercurial gage.	Bourdon gage.	Mercurial gage.	Bourdon gage.	
1	455	27.58	27.9	107.8	102.45	105.0
2	455	23.90	23.9	141.6	141.6	143.8
3	455	21.22	21.4	156.05	155.3	158.9 *a*
4 *b*	455	.....	18.5	.....	167.2	170.9
5	455	14.9	15.0	179.5	179.2	181.5
6 *c*	455	11.2	11.0	189.6	190.1	191.7
8	455	8.55	8.0	195.7	196.9	196.1
7	455	11.3	11.0	189.3	189.95	190.7
8	200	7.5	7.2	198.1	198.7	191.5
9	450	8.35	.....	196.2	.....	195.7
10	250	8.5	.....	195.9	.....	188.8 *d*
11	445	27.1	27.5	114.1	108.4	111.5 *e*
12 *f*	150	27.6	28.0	107.5	101.7	116.7
13 *g*	450	27.3	.....	111.5	.....	111.4
14	450	27.2	27.6	112.0 *h*	107.6	110.0
15	450	—0.1″ water press.	.....	211.7	.....	211.8 *h*

a Gages and thermometer varying slightly, but in time with each other.
b Flying readings.
c Flying readings.
d As Engine slowed down the temperature fell and the vacuum increased.
e At slow speed the exhaust took time to cool from previous trial, but cooled quickly on raising speed.
f Speed dropped from 445 to 150. At first the temperature fell to 108 degrees and the vacuum rose to 27.6 inches by the mercurial gage. Afterwards, without any change in the vacuum, the temperature slowly rose to 116.7 degrees.
g Speed raised quickly. Vacuum fell slightly, and temperature also fell to 110 degrees quickly.
h Non-condensing. The temperature rose at once on starting engine.

temperature could be obtained. The same engine was used for these experiments as for the first set of those described in Appendix II. The pressure in the exhaust pipe was measured by a water U-tube in the case of the non-condensing experiments, and by a mercury vacuum gage when the engine was running condensing. The thermometer used was subsequently calibrated at University College by Prof. Beare.

After trial No. 15, the speed of the engine was gradually reduced—but no change occurred in the readings. The engine was then stopped; there was no change for about one minute, then the thermometer began to fall very slowly.

Appendix V.

Numerical example of method of calculating the fuel consumption when the B.T.U.'s per minute per I.H.P. are given.

It is stated at page 964 that calculations in respect of fuel consumption can be readily made when the thermal economy of a steam engine is expressed in B.T.U. per I.H.P. The following example is given by way of illustration:

A steam engine requires 235 B.T.U. per minute per I.H.P. The coal used has a calorific value of 12,000 B.T.U. per pound, and 70 per cent. of the heat in the coal is transmitted to the steam; or, in other words, 8,400 B.T.U. per pound of coal burnt are transmitted to the steam. Hence the coal required per I.H.P. per hour is $235 \times 60 \div 8{,}400 = 1.68$ pounds. This calculation is, however, based on the supposition that the feed is at the temperature of the exhaust of the engine, since the heat supplied to the engine is calculated from this temperature. The feed temperature may be higher or lower, according to circumstances, and an allowance must be made. This allowance is easily made in the case of saturated steam, because the total heat required per pound of feed does not differ much from 1,000 B.T.U., so that the correction is sensibly one-thousandth of the difference of temperature between the exhaust and the feed multiplied by the coal consumption obtained as above. Thus, supposing the feed in the above numerical example is 100 degrees Fahrenheit above the exhaust temperature (owing, say, to the

use of an economizer), the coal consumption will be $100 \div 1{,}000 \times 1.68$ less, or $1.68 - 0.17 = 1.51$ pounds per I.H.P. per hour. Or, again, supposing that in the case of a non-condensing engine the coal consumption works out to 2.32 pounds and the feed is at 62 degrees Fahrenheit, owing to there being no economizer or feed heater, the correction will be $\frac{1}{1000}(212-62)\,2.32 = +0.35$, and the coal consumption becomes 2.67 pounds per I.H.P. per hour.

In the case of superheated steam, the correction becomes

$$\frac{\text{feed temperature} - \text{exhaust temperature}}{1{,}000 + 0.48 \times \text{degrees of superheat}}.$$

Thus, taking the second example on page 962, and supposing that 9,000 B.T.U. per pound of coal burnt are transmitted to the steam, the coal consumption is, if the feed is at exhaust temperature, $215 \times 60 \div 9{,}000 = 1.43$ pounds of coal per I.H.P. per hour. If the feed temperature is, however, 320 degrees Fahrenheit, the correction according to the rule becomes $100 - 320 \div 1{,}000 + 0.48 \times 275 = -0.19$ nearly, and the coal consumption is $1.43 - 0.19 = 1.24$ pounds per I.H.P. per hour.

Appendix VI.

Numerical examples of the method of calculating the B.T.U. per minute per I.H.P.

The principal supply of heat from the boiler to a steam engine is effected by means of the steam entering the cylinders, but heat can also be supplied by the intermediary of jackets or reheaters. A portion of the heat thus entering the engine is returnable to the boiler. For instance, the exhaust steam from the cylinders can theoretically heat the feed water to the temperature of the exhaust, and in some cases live steam from a receiver is taken to heat the feed. In the latter case the heat returned to the boiler per minute is clearly the weight of feed water per minute multiplied by the number of degrees through which the feed is raised in temperature.

The heat returned by jackets and reheaters can be calculated if the weight of steam passing through them and the tempera-

ture at which the resulting water is returned to the boiler are known.

The expression "heat returnable" has been advisedly used, because in practice the heat actually returned to the boiler is generally less, owing to a variety of causes over which the engine has no control. For instance, in the case of a non-condensing engine, a feed heater may not have been fitted, or, if there is one, it may be unable to raise the feed to exhaust temperature. Such losses should not, however, be charged against the engine, but against the feed arrangements.

The following numerical examples show how the various quantities of heat referred to above can be calculated, and the heat supply to the engine obtained.

With one exception, the data have been obtained from the actual published tests referred to in each case. In many instances the published figures do not give the "temperature of the steam at the stop valve," or the "temperature in the exhaust close to the engine," as recommended by the committee. In such cases either the temperature in the boiler or in the condenser have been taken as equivalent for the corresponding temperatures recommended by the committee.

EXAMPLE 1.—NON-CONDENSING NON-JACKETED COMPOUND ENGINE.

Willans Trial C 80 ÷ 3.2 (Minutes of Proceedings Inst. C. E., Vol. xciii).

Data—	
I.H.P.	24.9
Weight of steam entering engine, pounds per minute	10.86
Temperature at stop-valve, degrees Fahrenheit	322
Temperature in exhaust, degrees Fahrenheit	213
Result—	
Total heat of 10.86 pounds of steam passing through the cylinders	12,800
Less heat returnable in feed from exhaust	1,980
Net heat supply per minute	10,820
B.T.U. per I.H.P. per minute (10,820 ÷ 24.9)	435

EXAMPLE 2.—CONDENSING NON-JACKETED COMPOUND ENGINES.

Engine of S. S. *Colchester* (Procedings Inst. Mech. Eng., 1890, No. 2).

Data—	
I.H.P.	1,980
Weight of steam entering engine, pounds per minute	717
Temperature of steam at stop-valve, degrees Fahrenheit	325
in exhaust, degrees Fahrenheit	135

Result—

Total heat of 717 pounds of steam passing through cylinders	847,000
Less heat returnable in the feed from the exhaust	74,100
Net heat supply per minute	772,900
B.T.U. per minute per I.H.P. (772,900 ÷ 1,980)	391

EXAMPLE 3.—CONDENSING JACKETED COMPOUND ENGINE.

Engines of S. S. *Iona* (Proceedings Inst. Mech. Eng., 1891, No. 3).

Data—

I.H.P.		645
Weight of steam through cylinders, pounds per minute		136.5
H.P. jacket (discharged into feed tanks)		6.2
Temperature at the stop valve, degrees Fahrenheit		373
in the exhaust, degrees Fahrenheit		90

Result—

Total heat of 136.5 pounds of steam passing through cylinders	163,000	
Less heat returnable in the feed from the exhaust	7,920	
		155,080
Total heat of 6.2 pounds of steam passing into H.P. jacket	7,420	
No heat is returned by jacket, water being discharged into feed tanks	0	
		7,420
Net heat supply per minute		162,500
B.T.U. per minute per I.H.P. (162,500 ÷ 645)		252

EXAMPLE 4.—CONDENSING COMPOUND ENGINE WITH JACKETS AND REHEATER.

Louisville Leavitt Engine (Trans. American Soc. M. E., Vol. xvi).

Data—

I.H.P.	643
Weight of steam through cylinders, pounds per minute	109
jackets, pounds per minute	12
reheater, pounds per minute	10
Temperature of steam at engine stop-valve, degrees Fahrenheit	359
in exhaust, degrees Fahrenheit	102
jacket and reheater water at return to boiler, degrees Fahrenheit	328

Results—

Total heat of 109 pounds of steam passing through the cylinder,	129,950	
Less heat returnable in the feed from the exhaust	7,400	
		122,550
Total heat of 12 pounds of steam into jackets	14,300	
Less heat returned (at 328 degrees)	3,600	
		10,700
Total heat of 10 pounds into reheater	11,900	
Less heat returned (at 328 degrees)	3,000	
		8,900
Net heat supply per minute		142,150
B.T.U. per minute per I.H.P. (142,110 ÷ 643)		221

EXAMPLE 5.—ENGINE IN WHICH STEAM IS ABSTRACTED FROM INTERMEDIATE RECEIVER TO HEAT THE FEED.

Imaginary Case. Condensing, non-jacketed.

Data—		
I.H.P.		1,000
Weight of steam in pounds per minute passing into engine		300
Temperature at engine stop-valve, degrees Fahrenheit		370
in exhaust pipe, degrees Fahrenheit		120
Rise in temperature of feed due to steam taken from receiver, degrees Fahrenheit		100
Result—		
Total heat of 300 pounds passing into engine		359,000
Less heat returnable in the feed from the exhaust	26,400	
Less heat returned from receiver steam by the feed	30,000	
Total heat returned		56,400
Net heat supply per minute		302,600
B.T.U. per minute per I.H.P. (302,600 ÷ 1,000)		302.6

EXAMPLE 6.—SIMPLE NON-CONDENSING ENGINE USING SUPERHEATED STEAM SCHMIDT MOTOR.

No. 6 Trial (Minutes of Proceedings Inst. C. E., vol. cxxviii).

Data—		
I.H.P.		19.85
Weight of steam in pounds per minute passing through the cylinders		5.64
Pressure of steam at engines, pounds per square inch (absolute)		131.6
Temperature of steam at engine, degrees Fahrenheit		674
in exhaust, degrees Fahrenheit		217
Result—		
Total heat of 5.64 pounds of saturated steam passing through cylinder	6,700	
Superheat of 5.64 pounds of steam passing through cylinders	880	
Total heat supplied to engine per minute	7,580	
Less heat returnable in the feed from the exhaust	1,050	
Net heat supply per minute		6,530
B.T.U. per minute per I.H.P. (6,530 ÷ 19.85)		329

NOTES.

SIMILAR STRUCTURES AND MACHINES.

Professor Archibald Barr, D. Sc., in a paper on the "Comparisons of Similar Structures and Machines," states as follows:

Powers and Weights of Similar Engines.—We have seen that similar cylinders, pistons, etc.—in fact, similar engines—are alike suitable to bear the same statical steam pressure. But the areas of the pistons are as the squares of the dimensions. Hence, the powers for the same piston speed are as the squares of the dimensions. The powers would be as the cubes of the dimensions for the same number of revolutions per minute. The stress in a fly-wheel rim, due to centrifugal action, is proportional to the square of the velocity of the rim, whatever be the diameter of the wheel. Hence, the stresses in similar fly wheels are of like intensities when the wheels revolve at numbers of revolutions per minute inversely as their diameters. A like rule will be seen to apply to all inertia stresses in similar mechanisms. Thus, in two similar engines the cross-sectional areas of the piston rods are as the squares of the dimensions, while the weights of the pistons, etc., are as the cubes. To produce like severity of stress due to inertia, therefore, the accelerations of the masses must be inversely as the dimensions. Now, suppose the engines to run at numbers of revolutions inversely as the dimensions—*i. e.*, at the same piston speed. Then the maximum speeds of the pistons will be the same, but the times taken to get up the speed will be in the ratio of the dimensions. The accelerations will, therefore, be inversely as the dimensions, and then, as we have seen, the severity of the inertia stresses will be the same in both engines. This result, coupled with what we have seen above regarding the steam pressures, leads to the important result that, mechanically, similar engines (neglecting the small statical effects of their weights) are alike suitable to work at the same steam pressure and at the same piston speed—that is, at numbers of

revolutions per minute inversely as their dimensions. The powers will then be as the squares, whereas the weights will be as the cubes of the linear dimensions.

In other words, the maximum powers of similar engines per ton of weight will vary inversely as the linear dimensions, or inversely as the square roots of the powers. We have, therefore, the important result that we can get a greater horsepower from 100 tons of metal by making it into a number of small steam engines than into one large one. I do not know whether the bearing of this upon the use of twin or triple screws is usually realized, but it is well known that the maximum power per ton of small engines is greater than that of large ones for the same steam pressure and the same piston speed.

In a paper read before the Institution of Civil Engineers, Sir John Durston and Mr. H. J. Oram gave some most interesting details regarding the performances of engines in different types of war vessels. The results are not strictly comparable, since the engines of the large and small vessels are not of the same design, and the steam pressures and piston speeds are somewhat different; still a rough comparison or contrast may be made. The four-cylinder triple-expansion engines of the first-class cruiser *Powerful*, working at a steam pressure of 207 pounds per square inch and a piston speed of 905 feet per minute, developed 25,900 horsepower. This works out to be 11.58 horsepower per ton of machinery. The four-cylinder triple-expansion engines of the torpedo-boat destroyer *Angler*, working at a steam pressure of 210 pounds per square inch, and a piston speed of 1,187.4 feet per minute, developed 5,971.5 horsepower, which works out at about 45.9 horsepower per ton of machinery. These small engines, if working against a resistance that would bring them to the same piston speed as the engines of the great cruiser, would develop about 4,600 horsepower—assuming the distribution of steam to remain the same—or, say, 35.4 horsepower per ton. Comparing the two engines on this basis, we have the ratio of the horsepowers per ton as 1 to 3.05, and the inverse ratio of the square roots of the horsepowers as 1 to 2.37. The agreement is as close as we could expect, considering

what may be included in calculations which are based on the weight of the "machinery complete," and that the engines are not quite similar in proportions. It will be observed that the power per ton developed by the smaller engines is even greater in comparison with the power of the larger ones than our formula would lead us to expect. This may be partly due to a less economical distribution of the steam, and partly to a smaller margin of safety in the smaller engines, and partly to the fact that the smaller engines are designed for a higher piston speed, which would mean that they will be of lighter construction and of superior materials.

We see also that the same rule would apply to similar boilers, though, of course, large and small boilers are not usually made even approximately similar in design. The grate area and heating surface would increase as the square of the linear dimensions, whereas the weight of boiler and of the contained water would increase as the cube. The bearing of this upon the question of having a large number of small boilers in a ship instead of a small number of large ones, is very important.

Now apply these results, and those above deduced with respect to bodies falling in air, to the flying machine problem. It follows from what has been said above, that the weights of the aëroplanes or other supporting parts of flying machines, would require to increase more rapidly than the cubes of the linear dimensions (assuming that the smaller has the thinnest planes, &c., that will do), and that the power required to support even similar machines in the air would increase in higher ratio than the cubes of the dimensions. But the maximum power of similar boilers and engines would only be as the squares of the dimensions. Hence we see that, as with Nature, it is easy to make a small flying machine, but exceedingly difficult to make a large one. When we hear that someone has made a successful flying machine, we should inquire into its scale. A success with a model by no means indicates a similar success with a full-sized apparatus. Mr. Maxim seems to be the only one who has sufficiently realized this aspect of the problem, and has demonstrated experimentally how a flying machine, of what we may call full size, may be constructed.

UNSERVICEABLE INVENTIONS.

So long as hope springs eternal in the human breast, so long as man is ambitious to improve his material condition, or so long as inventors, those "who seek to add their part to the progress of human happiness, knowledge and power by improvements on things existing or new departures on untried lines" exist, so long will inventions be produced, be they wise or otherwise. That the object sought is usually of a mercenary character will be conceded; that the results attained are largely financially unfortunate is due to a number of causes not difficult to suggest. It is a sad commentary on the fatuity of the human mind to take note of the overwhelming preponderance of patents that answer no valuable purpose.

A large proportion of alleged inventions are by people utterly unacquainted with the subject, either technically or practically. A sailor would not be expected to satisfactorily plan an agricultural implement, yet he may not be legally restrained from the attempt. The Patent Office asks no questions concerning the inventor's business, knowledge or training, as, indeed, it could not well do. Its only requirements are that the invention must be novel, in the sense of not having been publicly known for more than two years; useful, which it interprets quite differently from the usual accepted meaning, holding it to be synonymous with harmless; and the actual personal product of the petitioner. It claims and attempts no censorship on the practicability, worth, value or usefulness of an invention, and, in this respect, its actions may be considered wise, for the things regarded by many as foolish to-day may be looked upon differently to-morrow. Therefore, no hope can be expected from this quarter in lessening the number of unwise and unprofitable patents; neither can the attorneys, nor middlemen, be expected to turn away the dollars of prospective clients, although it is believed that most solicitors who value their reputation and are sufficiently competent will, if desired, point out, diplomatically perhaps, faults and fallacies, even at a loss to themselves.

Fully 90 per cent. of the total number of patents granted may

be truly said to be unserviceable inventions. These may be subdivided roughly into three classes:

First, those which are suppressed by being bought up by competitive concerns, who may prefer to make use of some inferior device, possibly, rather than exploit the later invention. This is the case with numerous inventions, especially relating to domestic and automatic machinery, made in large quantities, for which an expensive equipment for manufacturing may be necessary. Examples are to be found in typewriters, telephones, registers and similar mechanisms owned and controlled by large corporations. A knowledge of these inventions is usually sedulously kept from the general public. It may be said that as this class is but little known and has never been in use, the public has lost nothing, because it never had the invention in use. Be it remembered that it is a fundamental consideration that a patent, to be valid, must be new. Again, the inventor usually realizes something, financially, for his labor in these cases.

Second, those inventions which are simply and easily made, those in the nature of personal belongings which anyone can make with little fear from the law in so doing. These, unless in the hands of parties able and prepared by experience and equipment to manufacture and place on the market in large quantities and at low prices, might as well have never been conceived, so far as profits go, by the inventor. Examples of this class are found in mechanical instruments, calipers, gages, etc., the variety of which is almost as large as the number of individuals making them.

Of the third class, to which the great majority belong, are those inventions which are inherently useless from their lack of practicability, either in construction or use. Examples are to be found in every possible field of contrivance. If one successful invention is made it is sure to be followed by a crop of would-be rivals, each certain that his idea is superior. Yesterday it was cycles; to-day it is automobiles; to-morrow something else. There is no doubt but that the calling out of a large number of ideas on one subject is an excellent thing; that many of these ideas should be unserviceable is to be expected.

It is believed that we might profitably weed out most of these useless patents, and probably force some of the more meritorious into use, by following the practice of the majority of foreign countries, in either obliging the working of a patent within a specified length of time, under penalty of forfeiture, or in imposing a system of annually increasing taxes. The new patent law of Austria does the latter, Germany does both, while Great Britain depends upon taxation to remove her useless inventions.

Another valuable custom which we might beneficially borrow is that of compulsory licenses, whereby if a patentee finds that he cannot work his invention without using a previous patent he may ask for a license to use the same, granting in turn to the owner of the prior patent a license to use his own invention. This should be whenever failure of the patentee to grant licenses can be shown; whenever the patent is not being worked; or the reasonable requirements of the public with respect to the invention can not be supplied. These compulsory licenses may be ordered on such terms as may be just, according to the circumstances of the case, in fifteen foreign countries, including several which have lately revised their patent laws.

It would also seem that some steps should be taken to debar from soliciting such attorneys as persist in offering premiums, prizes and the like, and by blatant advertising seek to allure and entrap the unsophisticated into vain attempts at invention. The advice offered by many, to "Protect Your Ideas," would far more wisely and reasonably read, "Perfect Your Inventions." It is a fallacy that is almost universally believed, that it is the course of wisdom to hurry an invention into the Patent Office. While this course may be wise in a few instances of a special nature, it is unwise with the majority of inventions, as the Government allows two full years of time in which to perfect the same. During this time an inventor may experiment and exploit as much as he likes, prove or disprove his theories, improve and add to his invention all that his experiments may disclose, and may even dispose of his prospective rights, without any disparagement to his patent privileges.

Should this course be taken, our Patent Office would not be so largely filled with what we have termed Unserviceable Inventions.

[We are in entire sympathy with the policy of taxing patents for the object described and for the benefit of inventors. It is of common occurrence for a successful inventor to find himself at the mercy of the owner of some old, but in itself useless, because impracticable, invention. The first inventor produced nothing of value, except as the second gave it value, and yet the second must pay the first for his own work! The system which keeps thousands of useless patents alive for no other purpose than to embarrass future inventors cannot be successfully defended. We have, however, no faith in the plan of requiring patents to be worked. Many alternative patents are taken out for the same purpose and by the same inventor, the intention being to make the best only, but to prevent others from making something nearly as good. This we regard as legitimate, and, in fact, many cases arise in which the inventor's interests can be protected in no other way. Again, the adoption of improvements often involves discarding devices which, while inferior, yet could not properly or safely be given to competitors, and to require the old devices to be made would discourage the adoption of new ones. Moreover, the requirement is a dead letter, so far as its real objects are concerned. This provision is in force in Canada, and we know of a case in which to meet it the inventor made *one* machine there and then stored it away. The patent had been worked (!) and anyone wanting the machine was at liberty to buy it, and in case of a sale a second one would have been made, so that the manufacture would have been "continuous," as required by law. In point of fact, the existence of a machine was not known to the public, and it was never sold, and certainly the law could hardly require the inventor to make it known by advertising it; and if it did, the advertising could easily be done on the same scale as the manufacture. The requirements of the law had been met, however, and the patent protected, and in his own good time the inventor sold it, and real manufacture under it was begun long after it would have expired if the patent had not been "worked." What is the use of being an inventor if one has not enough in-

genuity to get around a law like that?—ED.]—W. E. Willis, in the "American Machinist."

SMOKE PREVENTION AND BOILER RATING.

The Proceedings of the Engineers' Society of Western Pennsylvania, just issued, contains the recommendations of the Committee on Smoke Prevention appointed some months ago mainly to furnish a rule for the rating of boilers. The committee has gone quite carefully into the subject, collecting information and data from makers of boilers and automatic stokers, besides consulting with experienced engineers.

In the matter of rating of steaming-producing plants, the following three divisions were discussed: (1) Heating surface per horsepower; (2) grate surface per horsepower, and (3) amount of draft. The committee did not think it wise to recommend any fixed amount of heating surface per horsepower, partly because some boilers are working economically with less than the usual surface usually recommended per horsepower; that is, for a horizontal tubular, 12 square feet, and for water tubular, 10 square feet.

In regard to the area of grate surface per horsepower the committee recommends the following: (1) Run of mine, $\frac{1}{6}$ to $\frac{1}{5}$ square foot per horsepower; (2) slack, bituminous anthracite, $\frac{1}{4}$ to 5 square feet per horsepower, the air space in the grate being taken at 50 per cent. For mechanical stoking the rate should be the same.

Regarding the third matter, the committee finds that in all cases the draft should be measured not in the stack nor in the ash pit, but in the furnace over the fire and with the furnace door closed and the ash-pit door open when working the grate at the above-mentioned rate. When thus measured in unfavorable weather the minimum should be $\frac{3}{8}$ inch for run of mine and $\frac{1}{2}$ inch for slack.

Regarding smoke prevention the committee reached the following conclusions:

1. In an ordinary furnace smoke may be made very light by careful hand firing, yet in practice this cannot be obtained con-

tinuously, and the use of special furnaces or appliances should be insisted on and made compulsory by law.

2. The best method of preventing smoke is to burn the fuel in a separate chamber, so that the combustion is complete before the gases touch the surface of the boiler.

3. Where this method is not practical, as in boilers already set, and where there is no room, the best results are obtained by mixing the smoke, as it passes from the furnace, with heated air, the effect of which increases the temperature of the smoke as the temperature of the air increases, thus burning the smoke.

4. That as, even with special furnaces of the above types, with hand firing, the combustion is irregular and hence some smoke must be produced at times, the use of mechanical stokers is strongly recommended, especially in all plants above 100 horsepower.

5. As mentioned above, there is a lower limit of grate area per horsepower, below which the furnace is not heated enough to insure complete combustion and smoke is thus produced. For this reason all plants should be subdivided into two units at least, in order that the boilers may never run at a lower activity than one-third of their rated horsepower.

FOUR IMMENSE DRY DOCKS—LEAGUE ISLAND, MARE ISLAND, BOSTON AND PORTSMOUTH.

Under the direction of Rear Admiral Mordecai T. Endicott, the Bureau of Yards and Docks has now under way or plans prepared for the construction of four dry docks—League Island dry dock, Mare Island dry dock, Boston dry dock and Portsmouth dry dock. The first two named are to be of timber and the last two of concrete and masonry. Each pair considered in itself is almost identical; and therefore a description of one is a description of the other. Reference is first made in the following paragraphs to the League Island dock.

There has been much criticism because the League Island dock is to be built of timber. The Bureau itself is in favor of a concrete and masonry dock, but the specifications prepared by Con-

gress provide for timber. The recent collapse of the New York dry dock, however, has given the country a warning, and considerable influence will be brought to bear upon Congress to change the specifications. The Government, therefore, reserves the right to modify the construction of the dry dock from one of timber to one of concrete and stone, should Congress so authorize, and in the event of such a change being made the Government will reimburse the contractor for the increased outlay in cost. Bids were recently opened for the construction of the League Island dry dock, but the Bureau has deemed it expedient to reject them all.

The most popular description of a dry dock is to say that it is a coffin-shaped hole in the ground lined up with timber and fastened to piles. Piles are driven at accurate spaces at the bottom of the excavation, and the evidence of their security lies in the fact that at the last blow of the hammer, weighing 3,000 pounds and falling 25 feet, the penetration shall be not more than $\frac{1}{2}$ inch. Transverse timbers are then put on top of the piles and longitudinal timbers on top of the transverse and then a flooring of 3-inch planks. All of the transverse timbers are to be in not more than three pieces, securely fastened together with scarfs and bolts. On top of the timbers rest the keel blocks, spaced 4 feet apart, and on the side are the bilge blocks, spaced 16 feet. The heads of the foundation piles will be surrounded by a continuous bed of concrete at least 3 feet thick and extending up the sides in the body of the dock to the foot of the fifth altar.

The whole flooring will be surrounded by sheet piling and in the sides of the excavation inclined piles will be driven, and to these will be fastened the braces which carry the sides of the dock. These sides are composed of altars which have 11 inches rise and 9 inches tread, making a continuous stairway from the coping to the floor. The sides of the dock also have timber slides for sliding material down from the top to the bottom, and at each slide is an electric capstan for letting the material down into the dock. The caisson, or floating boat gate, of the dock, will have eight watertight compartments arranged for flooding or emptying as desired, thereby making it a floating or sinking

structure. It contains its own power for flooding or emptying its watertight compartments and operating the capstans and other mechanism. It will be built of open-hearth steel and will maintain an even keel under all conditions of flotation or submergence. Dimensions of the caisson are: Length, extreme, 106 feet $8\frac{7}{16}$ inches; breadth molded, 22 feet; depth from bottom of keel to underside of upper deck at the side, 37 feet 9 inches. The hull of the caisson will be fitted and completed with centrifugal pump, locomotive boiler, vertical engine, feed tank, capstans, trimming tanks, gate valves and culverts, drains, hatches, air pipes, concrete and movable ballast, bitts, deck cleats, scuppers, aprons, air ports, stanchions and guard chains. The caisson will contain 509,000 pounds of structural steel and 596,700 pounds of concrete for stable flotation.

To pump out the dock a large centrifugal pumping plant will be established and will be driven by electric motor with power supplied from a general power station. The pumps will be situated in a circular well, about 53 feet in diameter, with floor level of pump well about 36 feet below the level of the ground. The pumping plant will consist of three centrifugal pumps for pumping out the dock, with separate motors, all independent, and one centrifugal drainage pump and motor. These pumps admit water on both sides of the runners and give a discharge of 43,000 gallons a minute for each pump.

The only distinguishing difference between this dock and the one at Mare Island is that the Mare Island pumps will be driven by steam. General dimensions of the League Island dock are:

Length on coping from head to outer-gate sill, feet	750
Length on floor from head to outer-gate sill, feet and inches	717– 9
Width on coping in body, feet and inches	144– 6
Width on floor in body, feet	80
Width on coping at abutment, least, feet and inches	104– 3
Width at entrance on mean high-water level, feet	101
Depth from coping to mean high water, feet and inches	6– 6
Depth from coping to floor in body, feet and inches	40– 3
Draught over sill at mean high water, feet	30

PORTSMOUTH, N. H., AND BOSTON DRY DOCKS.

No piling whatever is contemplated for the Portsmouth dry dock. The bottom and sides will rest on solid rock, which has to be blasted out. This dock will doubtless be one of the most stable things in Christendom. The stone masonry of the body of the dock will consist of granite. The bottom and sides will be composed of granite and the interior lined with granite ashlar. The stone masonry of the walls and entrance will be ashlar in continuous courses, and is to be rough pointed on the face and fine pointed on altar treads and on floor. The altar system will be different from that of the League Island dock, having deep altars of 4 feet with the lower portion made up of a number of low altars.

The keel blocks, bilge blocks and bilge-block slides are to be of white oak, and all fittings for them will be of composition. They are to be spaced the same as in the timber docks. The entrance to the dock will be closed with a caisson or floating gate. The change of shape is slight, the corners being rounded off, while in the timber dock they are not.

The pumping plant, which is almost identical with that of the League Island dock, will be driven by an electric motor with power supplied from a central power station. To facilitate the hauling in of the ship and the handling of her while she is being docked, there are placed at the entrance of the dock and at the head three electric winches and along the side, at each timber slide, is placed an electric capstan, and bollards are spaced at intervals about the dock.

The Boston dock differs from the Portsmouth dock only in that it is built upon compacted clay with heavy concrete foundation. Dimensions of the Portsmouth dock are:

Length on coping from head to outer-gate sill, feet	750
Length on floor from head to outer-gate sill, feet	725
Width on coping in body, feet	130
Width on floor in body, feet	80
Width on coping at abutment, least, feet and inches	101– 9
Width at entrance on mean high-water level, feet	100
Depth from coping to mean high-water level, feet and inches	5– 3
Greatest depth from coping to floor in body, feet and inches	39– 3
Draught over sill at mean high water, feet	30

The Boston and Mare Island docks are now under way and bids are being solicited for the Portsmouth and League Island docks. These docks, when completed, will accommodate the largest thing afloat, including the auxiliary cruisers and the monster *Oceanic*.

The following is a table showing the United States naval docks already in existence:

UNITED STATES NAVAL DRY DOCKS.

Character.	Station.	Material of construction.	Length on floor.	Width of entrance at coping.	Depth over sill at mean high water.
			ft. ins.	*ft. ins.*	*ft. ins.*
Balance.....	Portsmouth, N. H....	Wood.....	350- 0	90- 0	25- 0
Graving.....	Boston, Mass.....	Granite.....	367- 5½	60- 0	24-10
Graving.....	New York, N. Y.....	Granite.....	338- 3	66- 0	25- 3
Graving.....	New York, N. Y.....	Wood.....	459-10	85- 0	25- 6
Graving.....	New York, N. Y.....	Wood.....	626- 8	105- 2⅞	29- 0
Graving.....	League Island, Pa...	Wood.....	459-10	85- 0	25- 6
Graving.....	Norfolk, Va.....	Granite.....	302- 9	60- 0	25- 0
Graving.....	Norfolk, Va.....	Wood.....	459-10	85- 0	25- 6
Graving.....	Port Royal, S. C.....	Wood.....	459- 0	97- 0	26- 0
Graving.....	Mare Island, Cal.....	Granite.....	459- 0	80- 6⅞	27- 6
Graving.....	Puget Sound, Wash..	Wood body, masonry ent..	618- 6	92- 7⅛	30- 0

—"Marine Review."

The "Engineering News" of September 28th states that the Portsmouth, N. H., stone dry-dock contract has been awarded by the Navy Department to John Peirce, of New York, for $1,089,000. Mr. Peirce owns the granite quarries at Frankfort, Me., and he is President of the company owning the Hallowell, Fox Island and Stoney Creek granite quarries, also in Maine. Work is to begin within 60 days and the concrete dock is to be lined with about 600,000 cubic feet of cut granite.

ALGIERS FLOATING DRY DOCK.

The floating dock which is now under construction by the Maryland Steel Co. at Sparrow's Point, Md., and which is to be

stationed at Algiers, La., is the largest floating dry dock in the world and is designed to dock the greatest battleship or armored cruiser afloat. It will lift a ship of 15,000 tons. At present the Government has no ship in its service of that tonnage, but it is quite likely that within a very few years it will have. The dry dock is therefore being built for the future.

The dock itself consists of five pontoons, comprising three pontoons which form the main lifting portion of the dock and two side walls which serve to give the dock stability. The pontoons themselves are of different size and form. The center pontoon, which is 240 feet long, is rectangular in shape, but the terminal ones have each only 80 feet 6 inches of their length rectangular, the remainder being finished off in the form of a bluntnosed point or bow. For a length of 55 feet these pontoons are also buoyant, but the remaining or outside 30 feet, forming the point proper, is formed by a series of plates and lattice girders of strong construction that support the ends of a ship without at the same time giving any buoyancy to the ends of the dock when short vessels are placed thereon. These end platforms have, however, the deck plating watertight, and are surrounded by watertight bulwark, which runs around the whole of the end of these pontoons.

The pontoons of the dock are divided into thirty-two pumping divisions, of which twenty-four are absolutely watertight and distinct. The sidewalls have each four watertight divisions. All these forty divisions are provided with a separate pipe, each governed by a separate valve. All the pipes in the starboard half of the dock are led directly into the main drain in the starboard wall and all in the port half to a similar drain in the port wall. These drains are continuous over the whole length of the walls, and the four pumps in each wall are seated directly in them so that any one pump can empty all the compartments of its half of the dock. In the event of a breakdown of a half the other half could empty the whole deck.

A separate engine is provided for each pair of pumps and a separate boiler for each engine. The steam pipes are, however, so arranged that either engine can take its steam from either

boiler. This duplication prevents a complete breakdown. Steam is the only motive power used in the dock. Although the dock is divided into forty sections, each with its own regulating valve, the work of the whole dock is done from two central positions on the top of the towers. Each valve house is in direct communication by speaking tube with its engine rooms, so that the man in charge can manipulate every valve, both water and steam, for the maneuver of the dock without quitting his post.

The dock floats at a draught of 4 feet. The valves are opened and the dock sinks bodily. It sinks to such a depth from floor line to top that it will take a ship of 30 feet draught, leaving it only 4 feet out of water. The dock is built of steel plate and angles. Great care must be exercised to see that the ship centers on the keel blocks. Then the pumps are set to work and the water is pumped out of the watertight compartments. The operator must see to it that the dock remains perfectly level. This can be regulated by shutting off a pump and leaving water in as a counterbalance. The watertight compartments have great value in controlling balance. Having seen that the keel of the ship and the keel blocks are even, as the boat comes out of water shores are put in place to give additional steadiness to the sides of the ship. When the deck of the pontoon is 2 feet out of water the surface of the ship is actually 6 feet out of water when one gets ready to work on it.

One of the great features of the dock is its self-docking qualities. Provision had to be made for this, for like any other vessel it could get out of repair and there is no dock in the world large enough to receive it. If one wants to dock the middle pontoon, the lugs and fish plates are disconnected and the pontoon is allowed to float loosely. The pumps are disconnected and the opening closed by valves. Then water is admitted to the side walls and the middle pontoon floats up. The side walls are sunk until the lug at the bottom of the middle pontoon corresponds to an upper lug on the side wall. The middle pontoon is therefore entirely out of water and access can therefore be had to any part of it. The middle pontoon has sufficient capacity to dock both ends at once. One of the side walls can be tilted out of

water by filling the other side. The dock is entirely complete in itself, with engines, boilers and quarters for crew, and is anchored just like a ship. It can be towed anywhere. It will be towed to New Orleans, and stationed at Algiers.

This floating dry dock will be a particularly valuable feature in case of war, for it will dock the largest battleship. Had it been built at the time of the Spanish-American war it might have resulted in the saving of the *Maria Theresa*. The dock is 525 feet long and 52 feet high, and has a clear width between walls of 100 feet. Its lifting capacity is 15,000 tons.—"Marine Review."

GAS ENGINES FOR SHOP DRIVING.

The rapid and substantial advancement of the gas engine as a power producer for machine and generator driving will surprise those who examine its present status with a view of using it to replace steam. By many who are not informed as to its progress it is regarded as too experimental and too uncertain for consideration as a source of power for running machines which must work every day and must not be stopped for breakdowns. The gas engine is very far from perfect, but it has now reached a stage which warrants its consideration as a reliable motor which is cheaper than the steam engine in fuel cost and attendance, and in addition to these advantages it offers a means for subdivision of power that is equal in efficiency, if not superior, to that of electricity.

The reliability of the internal combustion engine is proven by those that are running all day long without stopping, and many are running in buildings which are closed and locked, except when the attendant comes to oil them. A 65-horsepower Westinghouse gas engine has made a wonderful record for long continuous running, which has probably not been approached in severity by any steam engine running in regular service. The one referred to is in New York City, and from October 15, 1898, to February 28, 1899, it averaged 22.3 hours running per day for 137 days. During this time it was idle but 230 hours, and only 49 of these were required in repairs to the engine. We are told

that 26 hours were spent in replacing the igniters with new ones, and 12 hours were given to the bearings and adjustment of other parts. A continuous run of 638 hours, ending February 19, is recorded. It is not necessary to say more with regard to reliability, because that engine was working under conditions more exacting than are usually confronted by steam engines.

The gas producer furnishes means for operating gas engines independently of city mains, and oil or distillate may be used where it is difficult to secure appropriations for the gas plant. The attendance required for a gas producer is less than for a boiler, because the operations are almost entirely automatic. Mr. A. R. Bellamy gives valuable records from the daily operation of a plant in England, including two 40-horsepower gas engines driven by producer gas. Two-thirds of a cent per indicated horsepower hour cover all charges for operation, where anthracite coal costs $6.25 per ton. The producer makes 1,000 cubic feet of gas from 14 pounds of coal, including all losses, and the two engines, the producer and a steam boiler (for operating steam hammers), were attended by one laborer. The same expense for attendance would be ample for double this amount of power. The engines in this case are looked after by an uneducated man, who gives them less than two hours per day. The cost of the gas may be placed at 6½ cents per 1,000 cubic feet. The consumption of fuel is 0.939 pound per indicated horsepower per hour, including all losses, and against this may be placed the wasteful single-expansion steam engine with disgracefully long steam pipes. It is well known that many such engines have been struggling for years at an expense of from five to eight pounds of coal per indicated horsepower hour.

Mr. Bellamy records valuable figures for electric lighting. The power used in the case cited is 18 brake horsepower. At 83 cubic feet of fuel gas per brake horsepower hour and an average of 20 hours per week, the cost was less than ten cents per hour for 38,000 candlepower in arc lamps and 496 candlepower in incandescents. The efficiency attained by the Westinghouse gas engine, as reported by Mr. Edwin Ruud, for engines of 20 horsepower and upward with natural gas is from 10.5 to 12 cubic

feet per brake horsepower hour and a special 125-horsepower engine has given the phenomenal economy of one brake horsepower for 9 cubic feet. This gas gives 1,000 British thermal units per cubic foot, and the best record is an efficiency of 28.7 per cent., while 33⅓ per cent. is promised for every-day performance.

The figures for the operation of oil engines, including all charges, are not available for comparison, but we have Professor Denton's authority, based on a test of a 20-horsepower Diesel motor, expressed in his report as follows: "As the motor shows itself to be able to use oil obtainable at about two cents per gallon, the cost of a brake horsepower may be two-tenths of a cent per hour, which is slightly less than the cost of the same power from the average triple-expansion steam engine, with coal at $3 per gross ton."

The proposition before a shop manager who is planning improvements or entirely new shops is this: Will it be a good investment to install a gas-engine equipment for the entire power plant, put in a gas producer and also provide a steam plant for heating in the winter? The man who does this may be considered bold, but he has excellent precedents and will undoubtedly save money by it. The gas producer may be run when needed, and by providing sufficient storage no gas need be made when only a part of the engine equipment is running. This simplifies night work. The subdivision of power by gas engines is easy and economical, and gas fuel may be distributed much more easily than power. Quoting Mr. Bellamy again: "One horsepower at the gas plant is sufficient to force through mains one mile long, sufficient to supply 3,000 horsepower. It is probable that in certain cases it will be cheaper to run small outlying shops of a large plant by gas engines than to drive by electric motors from a steam-driven generator."

A little study of existing records reveals a most promising prospect for the internal-combustion engine, whether the fuel is oil or producer gas, and the outlook for producer gas made from the cheapest forms of anthracite, down to the size known as buckwheat, is exceedingly bright. The illustrated descrip-

tion of the producer and gas-engine plant at the Jersey City terminal of the Erie R. R. in this issue is worthy of thoughtful attention in this connection.—"American Engineer and Railroad Journal."

EFFICIENCY OF WATER-TUBE BOILERS.

The discussions which have taken place in Parliament and in the daily press on the subject of water-tube boilers, have been chiefly instrumental in demonstrating the ignorance of novel conditions of those who opposed the new system. Many, if not the most of them, have written as if the subject of debate were the relative merits of the Scotch and the water-tube boilers. Now, on that matter, we imagine, there is no doubt. From the point of view of the seagoing engineer, the Scotch boiler is far away the better of the two, so long as it is not forced. But it is just this last condition which cannot be secured. The naval tactician demands speed, while the naval architect can only allow the engineer a very moderate portion of the displacement for his engines and boilers. Hence, each ton of boilers must be made to furnish more steam than it does on board a merchant ship. If our ocean liners had one-third of their boilers taken out, and were still required to make their usual speed, they would be pretty much in the position of Her Majesty's fleet when it is ordered to go at full speed. The relative conditions of naval and mercantile vessels are well shown in a Parliamentary return issued some little time ago by the Admiralty. In this, ships fitted with water-tube boilers are compared with similar vessels having cylindrical boilers. In a table referring to battleships we find that the average of vessels containing cylindrical boilers, built after the Naval Defence Act, gives 7.8 indicated horsepower per ton of machinery, complete with boilers, for natural-draft trials, whilst each ton of weight of boilers complete (exclusive of engines) gives 14.4 indicated horsepower. In other words, the weight for each indicated horsepower developed is 132 pounds for engines and 156 pounds for boilers, giving a total of 288 pounds weight of machinery to produce each unit of power. If we compare this with the average

of that of six ships of the *Canopus* class, fitted with Belleville boilers with economizers, we find that when developing the natural-draft power, 10.5 indicated horsepower per ton of machinery complete was developed, whilst for each ton of boilers complete 21.7 indicated horsepower were developed.

Taking the figures in the other way to correspond with those already quoted, we find the weight for each unit of power developed was 111 pounds for the engines and 103 pounds for the boilers, giving a total of 214 pounds of total weight of machinery for each indicated horsepower. The comparison is not, of course, complete; the sizes of the engines were different and the pressures also were not the same. In the case of the cylindrical boilers the total power exerted by the machinery in the instance quoted was a little over 6,000 indicated horsepower, with a power similar to that exerted in the case of the Belleville boilers the figures as to weight come closer together, but the cylindrical boilers then had a pressure of 0.27 inch of air for urging the fires. Of course comparisons such as these may easily lead to erroneous conclusions, but we take it that the Admiralty engineers design machinery most suitable for the ship, and, if we allow this, the comparison is strongly in favor of the water-tube boiler, supposing the assumptions are borne out, as they doubtless will be.

In the case of the battleships, the coal consumption of the vessels of the *Canopus* class is naturally not given; but in a second table, in which first-class cruisers are dealt with, we have a column "Coal per Indicated Horsepower per Hour." It is, of course, in coal consumption that the water-tube boiler is most open to attack by its opponents. The Admiralty return, however, hardly supports the contention. Running down the table of coal consumption of first-class cruisers, we find that with the cylindrical boiler the best consumption quoted is 1.70 pounds of coal per indicated horsepower per hour. This is practically equalled by the *Terrible's* record of 1.71 pounds, and several other ships fitted with Belleville boilers show almost the same figure. It is, however, exceeded in value by that of the *Diadem*, which burnt only 1.61 pounds of coal per indicated horsepower per hour. The *Niobe* gave even a better figure; her best record being 1.55 pounds,

whilst the *Amphitrite* heads the list with 1.43 pounds of coal per indicated horsepower per hour. The latter, we think, is the best record that has been obtained with any vessel in Her Majesty's Navy. At any rate, it is the best in the return under consideration.

There is another point to which we would make reference in touching in a cursory manner on this question of Navy boilers. It is the fashion of some who pretend to instruct the public in these matters to write as if no accident ever happened to a cylindrical boiler, and there were no defects in its design and economy. It is needless to remind our engineering readers of the difficulties that arise with cylindrical boilers with the admission of salt water. But one would think, to read what has been written lately, that ordinary shell boilers were fed with nothing but salt water. We would refer those who hold that the smallest drop of salt water will immediately destroy a water-tube boiler, to the speech of Mr. Wingfield, made at the summer meeting at Newcastle of the Institution of Naval Architects. This gentleman, who is certainly a good authority on the subject, told us that not only may water-tube boilers have a certain proportion of salt water mixed with the feed, but that one vessel made a large part of the voyage to South America wholly with salt-water feed, and it should be remembered that these boilers were of the Express type, having small and bent tubes, a form which is considered by some eminently unsuitable for evaporating salt water. Of course, it is needless to tell engineers that no one puts salt water in his boiler, in these modern days of high pressures, if he can help it. No matter whether it is a cylindrical boiler or a water-tube boiler, there are tubes in each, the surfaces of which it is eminently undesirable to deteriorate with a coating of scale. But in the cylindrical boiler there are furnace crowns to come down, a matter so far more serious than the bursting of a tube, that it is more incumbent on the engineer in charge of shell boilers to avoid scaling than it is for the attendant on a water-tube boiler; that is, so far as safety is concerned.

We need not, however, labor this point. It is highly improbable that the old cylindrical boiler will again find its way into

warships, unless under exceptional circumstances. We cannot expect that there will be no further boiler accidents, even, unhappily, there may be some of a fatal nature. Dreadful as it is to contemplate loss of life and mutilation to human beings, yet that cannot stand in the way of the development of our Navy, which is the guarantee of our existence as a Nation. Not long ago we had in rapid succession two serious accidents in the engines of war vessels; one of these proved of a terribly fatal nature, and, though no life was sacrificed, through the first mishap, that was owing to good fortune, if such can be said in the case of men so terribly injured as those were through the first accident. No one, however, will suggest—certainly not the men of the Royal Navy, who are most liable to these accidents—that on this account we should abstain from building an undeniably delicate and intricate, yet most effective class of vessels; we refer, of course, to the torpedo-boat destroyer.—"Engineering."

THE ATBARA BRIDGE.

On April 20 last Sir Alfred Hickman, in the House of Commons, asked the Under-Secretary of State for Foreign Affairs for information as to the circumstances under which the contract for the Atbara Bridge was given to an American firm. No reply to the various questions was possible at the time, but they now appear in the form of a Government paper of unusual interest, and although the complete story was told by us some time since we return to the subject now that the official narrative is made public. The control of the Atbara bridgework was in the hands of Lieutenant-Colonel Gordon at Cairo, his agent in England being Colonel Western. As everyone knows, the Sirdar had, with characteristic energy, pushed forward a railway into the desert on the bank of the Nile, its immediate purpose being to aid in the great campaign, and its ultimate object, a terminus at Khartoum. The Atbara River interposed a serious obstacle, and the line could not be completed without a bridge, the erection of which was of extreme urgency. So urgent indeed was Lord Kitchener's requirement that he requisitioned for stock

material that would serve the purpose forthwith. Of course, this was not forthcoming, and plans and specifications were immediately prepared.

This was in October of last year, and on December 29 following, tenders for the work were received in Cairo. Seven offers were sent in, five from English, and two from American, firms; the prices per ton of the latter were 11l. 17s. 6d. per ton, and 13l. 11s. 6d. per ton; the English offers ranged from 16l. 12s. to 13l. 10s. per ton, in all cases, both English and American, with delivery at Liverpool. The time required varied from fourteen weeks to nine months. A mistake, however, had been made in the design of the bridge, which involved the necessity of heavy false works in the bed of the river—a condition which could not be accepted. Fresh tenders were, therefore, asked for, from the same firms, who were furnished with a very rough specification, the two necessary conditions being quickness of delivery, and erection by launching without any false works; price was altogether a secondary consideration. The specification was as follows:

"Provide for a train of two engines (as per diagram)* followed by train of 1 ton per foot run.

"Wind, 30 pounds on a train 11 feet high above the rails, plus the girder surface.

"Limiting stresses, 9 tons per square inch on net sections, calculating the working load as follows:

"Dead load plus live load by 1.5.

"Provided that the dead load assumed shall never be less than half the live load.

"The bridge is to be a through bridge, 14 feet clear width and 15 feet 6 inches headway, of seven spans of 150 feet clear, carried on cylinders 10 feet in diameter, the girders to be launched, but the continuity is not to be permanent. Launching strains not to exceed 9 tons."

From the foregoing it is evident that manufacturers were left an entirely free hand as to design, subject, of course, to the ap-

* See "Engineering," Vol. lxvii, page 770, Fig. 5.

proval by Colonel Gordon or his colleague, Colonel Western. From the commencement of the negotiations it appeared quite hopeless to expect anything like an early delivery from the English manufacturers, a delay of, at first, one year before completion in England, and afterwards of two years, being the conclusion unavoidably forced on the authorities. Nor were the two offers coming from America satisfactory as to early delivery. Colonel Gordon accordingly caused further inquiries to be made in America, and in consequence obtained an offer from Pencoyd (the first appearance of that company in the matter), guaranteeing delivery of a standard-type bridge in six weeks. This offer was shortly after modified in accordance with the specification quoted above, and on January 25, last, the revised results were in the hands of Colonel Western; they were as follows:

Phœnix Company, declined for early delivery.

Horseley, declined for early delivery.

Handyside, declined for early delivery.

Patent Shaft and Axle Company, 15l. 15s. per ton in English port, first span in two months; the others, one every three weeks.

Sanders, Pennsylvania, 10l. 15s. per ton United States port; time, three and one-half months.

Union Bridge Company, 13l. per ton United States port; time, sixty-five days.

Roberts, Pencoyd, $31,000 United States port; time, forty-two days.

Certainly Colonel Gordon spared no pains in giving every facility to English manufacturers, but competition was entirely out of the question. Colonel Gordon states in his report that one of the directors of the Patent Shaft and Axle Company, which had done all that was possible to secure the contract, called on him in Cairo, and asked what the result had been. "When I told him that we had placed the order with Pencoyd for complete delivery in six weeks, he told me that they could not possibly compete against such quick delivery, and that he doubted whether any firm in the United Kingdom could make as good an offer as they made (the Patent Shaft and Axle Company), as they were, he believed, the only firm in the United Kingdom that rolled

their own material, all the bridge makers having to depend for their rolling on outside firms, who might or might not be able to give preference to this work."

We have already given in full detail the story of the rapid construction of the Atbara Bridge in the shops of the Pencoyd Company; the last shipment was made on March 15, well within the time guaranteed by the makers.

The statements of Colonel Gordon effectually dispose of the absurd stories of favoritism to American makers, which have been circulated to excuse the deficiencies of our own manufacturers, while the equally absurd statement that while English makers were bound down to follow a prescribed design, Pencoyd was given a free hand, is also effectually contradicted. On the other hand, the opinion expressed by the director of the Shaft and Axle Company quoted above, must, we suppose, be accepted as correct.

We have seen that the question of the price paid for the Atbara Bridge was of very small importance; but it is of interest to compare the offers made by the Patent Shaft Company and Pencoyd. The price of the former was 15l. 15s. per ton delivered in an English port; the latter was a lump sum of 32,000 dollars, or, say, 6,400l. delivered at New York. The weight of the Pencoyd Bridge, including erection plant, was 1,507,000 pounds, or, say, 670 tons, making the price per ton 9l. 11s. To this has to be added freight to Liverpool, 1l. 2s. 6d., bringing the cost per ton to 10l. 13s. 6d. On this point Colonel Gordon says: "The price quoted by the nearest English firm was 10,400l. I may mention that this was calculated on the weight of the English bridge being the same as the American, but I now gather that it would have been about 200 tons more, and, at 15l. 15s. per ton, would mean an increase of 3,150l." It has been urged that the Pencoyd Company took the contract at a loss, but this is not so, and we notice that, even with the present great inflation of prices, they have secured a 10,000-ton contract for Japan at 15l. per ton.

It will be observed that the contract for the Atbara Bridge referred only to the superstructure, which rests on cylinders sunk under another contract. With reference to this, Colonel Gordon's report contains the following suggestive paragraph:

"I wonder that comment has not been made on the fact that the more expensive portion of the bridge was contracted for by an Italian firm, the answer to this being that there is only this single firm in Egypt possessing the required plant for sinking cylinders, &c.; and until a British firm sets up a plant in this country, I conclude that all bridges whose substructures are built as those of the Atbara and others will continue to be contracted for by this firm."—"Engineering."

CRYSTALLIZATION AND SEGREGATION OF CAST IRON.*

Mr. West has pointed out very clearly in his paper that the present method of selecting pig iron by fracture is defective and misleading. How is the structure formed which we see on breaking a pig? A molton mass of iron in the blast furnace, cupola or ladle is a combination of chemical elements, held in solution by the fluid mass of iron, just as salt or sugar is held in solution by water.

Each of these elements has a different melting point and point of cooling. Some of these elements are attracted to each other, thus forming a combination. As soon as the iron gets cool enough, crystals begin to form and try to extract out of the surrounding fluid metal all the elements necessary to their growth. The crystals grow as long as they have an opportunity to extract material for growth from the fluid iron surrounding them. Hence, if we cool iron quickly, we stop the crystals' growth while they are small. This is clearly shown by the samples exhibited here by Mr. West. The pieces of small cross-section have a fine structure, because they cooled quickly and the crystals had no time to grow larger. The larger sized sections have a coarse grain, because they had more time to grow, due to slow cooling. The fractures of the test bars exhibited by your committee on "Standard Tests," show the same phenomenon.

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* Extract from discussion of a paper on "The Deceptive Fracture of Pig Iron," by Mr. Thos. D. West, read before the American Foundrymen's Association. (See "Eng. News," May 25, p. 340.)

A couple of years ago I came across a very striking instance of the effect of time on cooling, on crystalline structure of iron and steel. A large part of the contents of an open-hearth furnace escaped through the bottom of the furnace. The bottom was repaired and the metal was left there until the furnace had to be torn down. Here was an opportunity for the escaped fluid metal to cool very slowly. As a consequence the crystals in that mass of soft steel were of extraordinary size. I obtained a well formed crystal, which measured 1⅜ inches, in length and ⅜ inch in width. I have still a piece of that metal with a crystal imbedded, measuring ⅜ inch. Ordinarily the crystals of such steel in the ingot measure only a few hundredths of an inch.

Such an instance furnishes proof of the importance and influence of time in cooling a molten mass of iron on the size of structure, irrespective of chemical composition. You can readily imagine the gradations in size of structure, due to time of cooling, between the crystal 1⅜ inches long, and the fine structure we might be able to obtain in the same metal by instantaneous cooling of the mass. For the same reason, an iron low in silicon may have as coarse if not a coarser fracture, than an iron high in silicon and graphitic carbon.

There is another property of cast iron with which foundrymen are much concerned, but which thus far has not received the attention it deserves. Cast iron is an alloy composed of iron and other substances. Now the melting point of alloys varies with their constitution. Thus wrought iron melts at 2,912 degrees Fahrenheit, gray iron at 2,280 degrees Fahrenheit, and white iron at 2,075 degrees Fahrenheit. An alloy of 1 part tin and 25 parts lead melts at 558 degrees Fahrenheit, while an alloy of 6 parts tin and 1 part lead melts at 381 degrees Fahrenheit. The melting point of tin alone is 451 degrees Fahrenheit and that of lead is 618 degrees Fahrenheit. Naturally, an increase in the number of elements in an alloy and variations in the percentages of elements will produce complications in the melting points of alloys. These complications are increased by the law of affinity, according to which certain elements will attract each other and combine with one another more readily than other elements.

They will flock together like birds of a feather, as the saying is. It must be obvious that, during the formation of such complicated combinations the rate of cooling again plays an important part.

But to fill the foundrymen's cup of bitterness and perplexities to overflowing sometimes, and to make him scratch his head in wonderment as to what will come next, there is the phenomenon of segregation in alloys, and cast iron is much affected by this phenomena. Iron, like water, has the ability to dissolve and hold in solution foreign substances when in a fluid state. But when a fluid mass of iron cools down to the point of solidification the foreign substances, held in solution while the iron was fluid, segregate out of the iron, one after another, the same as salt segregates out of the water, whenever there is more salt dissolved in a hot brine, than the water can hold when cold. Now the iron can hold more carbon, silicon, etc., chemically combined, when in a fluid state than it can hold in a solid state. Consequently, when a molten mass of cast iron freezes, such of the foreign substances held in solution by the molten iron as cannot be held by the solidified iron, will segregate out during cooling until the mixture reaches certain proportions. The mixture with these proportions which freezes last, is called the mother metal, in alloys of metal, and the mother liquor, in other mineral solutions, for cast and pig iron are nothing but mineral solutions after all.

According to Roberts-Austen and Jueptner von Jonstorff, the mother metal of cast iron is composed of 95.7 per cent. of iron and 43 per cent. of carbon. The mother metal of an alloy of copper and silver contains 28 per cent. of the copper and 72 per cent. of silver. Whenever, therefore, in an alloy, an excess of elements is present above the proportions necessary to form the mother metal this excess will separate, or segregate out of the molten mass, and solidify before the mother metal freezes or solidifies.

This is the reason why a plumber can make a wiped joint. If he would take a mixture of lead and tin, or whatever metals he uses, of such proportions as just to form the mother metal of a

tin-lead alloy, he could not make a wiped joint, because his mixture would solidify under his hands so quickly that no time would be left to wipe the joint. Having an excess of lead, however, this excess freezes first and continues freezing while the plumber is wiping the joint, until so much of the lead has frozen, or segregated out of the mixture, as to leave the proper proportion of metals to form the mother metal. When that point is reached the whole of the mixture freezes at once without any further segregating out of the one or the other metal.

Now this same action takes place in cast iron, or other alloys, and this segregating out of the excess of elements in alloys, over and above those proportions necessary to form the mother metal is a disturbing factor of unknown influence in the brass and iron foundry. On account of this, cast iron has two cooling points, instead of one. In other words, the excess of elements present, over and above the mother metal, solidify or freeze, first and at a higher temperature than the mother metal. For instance, a mixture of cast iron with 98 per cent. of iron and 2 per cent. of carbon will solidify at 2,408 degrees Fahrenheit; but if the iron is given time enough to cool slowly for the segregating out of the excess of iron over and above 95.7 per cent. of iron and 4.3 per cent. of carbon, which is the mother metal of cast iron, than that iron will solidify at two different temperatures, viz: the excess at about 2,408 degrees Fahrenheit, and the rest at 2,066 degrees Fahrenheit, which is the freezing point of the mother metal of cast iron. According to Charpy, bronzes may sometimes have three, or even four, freezing points.

The practical lesson for the foundrymen from all this is that if he knows he has the right mixture for a given purpose, to try and pour his iron at a sufficiently low temperature to prevent segregation as much as possible in large castings. Under unfavorable conditions such segregated castings, notwithstanding their chemical composition is all right, may be weak, because of the want of homogeneity of the structure. The casting may appear solid enough, but when a casting happened to solidify at two different temperatures, the structure or grain cannot be uniform throughout the mass, and there is liability to lines of weak-

ness running through the casting between the juncture of patches of coarser grain and finer grain.

We can thus readily see that it is not always the chemical composition alone that secures a good, strong and sound casting. We can also imagine what possibilities there are in alloys in general, and cast iron in particular, for the formation of an endless variety of combinations and complications due to this peculiarity of segregation in alloys of metals, and the greater the number of elements present the greater the liability for complexities.

INDIA AS A CENTER FOR STEEL MANUFACTURE.

[By Major Reginald Henry Mahon R. A. (Cossipore). Paper read before the Iron and Steel Institute, Manchester meeting.]

The object aimed at in this paper is to place before members of the Iron and Steel Institute facts relating to the possibility of manufacturing at a profit iron and steel in India.

If it can be shown that suitable material can be collected and worked into steel at a given center in India at a price not exceeding similar manufacture in Europe or America, it must then be conceded that such steel starts in the markets of the East with an advantage equal to the freights charges on imported material. This advantage would never be less than 12s. a ton, and would rise at times to 18s. There would, however, fall to be deducted from this the freight charges from the selected center to other ports; this deduction could not under any circumstances absorb the whole. The cost of the Suez Canal passage (say, 4s. per ton), and some gain due to decreased lead, must ever be on the side of local produce, even when distributed under the most unfavorable conditions.

India alone, as a market, is capable of taking a very large quantity of manufactured steel, and its requirements are certain to increase for a number of years. In the year 1897–8 the imports of rolled iron (including plates) was 137,000 tons, a very large part of which would be accepted in mild steel. During the same period rolled steel, excluding rails, was 80,000 tons; rails and fish plates amounted to 93,000 tons more. In addition

to this, 30,000 tons of pig iron and iron pipes were imported, and 43,000 tons of iron and steel sleepers. The sum total of these figures is 383,000 tons. Machinery and rolling stock for railways was also imported to the value of about 40 million rupees (about 2½ million pounds). Of the entire quantity of iron and steel imported into India, one-third of the iron and one-half of the steel comes from countries other than the United Kingdom.

The coal output has quadrupled during the last ten years, and now amounts to over 5,000,000 tons annually. The average cost price at the pits is Rs. 2 per ton (2s. 8d.). The greater part is good steam coal, and a coke can be made from it which is singularly free from sulphur (0.5 per cent.), and contains from 10 to 12 per cent. of mineral ash. It is hard, tough and well suited for the blast furnace. The best and largest coal fields, containing many thousands of millions of tons, are situated about 150 miles from Calcutta, and are connected thereto by more than one line of railway.

Iron ore exists in large quantities in several localities. Of these the three best known are:

1. The Salem District of the Madras Presidency, situated about 113 miles from the sea at Porto Novo, where there is no harbor, and about 199 miles from the port and harbor of Madras. These deposits are inexhaustible, and consist mainly of magnetite and hematite mixed with quartz. The ore is capable of being concentrated by hand-picking to a grade of from 55 to 60 per cent. of iron, 10 to 15 per cent. of silica, and unimportant amounts of sulphur and phosphorus. The small ore and tailings can be concentrated magnetically to 66 per cent. of iron and 3 per cent. of silica.

2. The Chanda District of the Central Provinces contains an inexhaustible supply of fine red hematite of 60 per cent. grade, but unfortunately situated so far inland as to be heavily handicapped. On the completion of certain railways at present projected, the rail distance between the ore and the east coast at Masulipatam will be about 360 miles.

3. *The Iron Ores of Bengal.*—These are widely scattered, and do not, as in the previous cases, occur in enormous masses at a

given locality. Their grade is from 40 to 50 per cent. of iron, and in many cases the ores are phosphoric. They lie, however, in proximity to the coal fields, and form the source from which the present Bengal Iron Works draws its supply, turning out a pig iron of which the approximate composition is:

	Per cent.
Silica,	2.26
Sulphur,	0.02
Manganese,	2.69
Phosphorus,	1.98

The limestones of India are not at present well explored. It is probable that any large ironworks would draw its supply from the Burmese coast, where quantities exist of a purity of 97 per cent. of carbonate.

In India the government minimum rail freight for goods is one-tenth of a pie per maund (80 pounds) per mile, or $2\frac{3}{4}$ pies per ton-mile, equivalent to a little under $\frac{1}{4}$d. per ton-mile. There is no doubt that for such traffic as would be necessary for the supply of a large work the minimum rate of carriage for ore and coal could be counted on. In the case of water carriage, the obtainable terms would probably be less satisfactory. The coasting trade is practically the monopoly of a single company, and their vessels are not adapted to the rapid loading and unloading of such cargoes as ore and coal. If any scheme that may be adopted involves coastwise carriage for any of the material, the promoters will do well to provide their own shipping specially designed for the trade.

After due consideration, it would appear that the neighborhood of Calcutta is the most favorable for the site of an iron and steel works. We have here a port open at all times of the year to shipping; the center of a great network of railways, spreading north, south, east and west; the greatest trade center in the East, and a labor market in which the natives have already been trained to the use of machinery, to ironfounding, and, in the case of one establishment, to steel making.

That Calcutta is 800 miles by sea and 200 miles by rail from

the Salem ore, and 150 miles from the Bengal coal and ore, need not alter the opinion expressed. Most of the readers of this paper are aware that conditions as unfavorable govern the manufacture of hematite iron both in England and in the northeastern States of America. Proximity to the sea is a factor of immense importance in any country, and proximity to a great center of civilization appears to the writer a factor of almost paramount importance in the East.

The conditions, then, which appear to offer the greatest prospects of success are the establishment of a steel works on a large scale, capable of undertaking the whole or a large part of the requirements of India, both as to rails, sections and plates, to be situated either on the Hooghly below Calcutta, or on the Mutlah River at or below Port Canning. This latter site has considerable advantages, which will be enhanced if, as is proposed, it becomes the coal export dépôt for Bengal, to draw the supplies of coal from mines owned by the steel company in Bengal, and the supplies of ore in great part from the magnetite deposits of the Salem district of Madras, and to some extent from the argillaceous ores of Bengal, the supplies of limestone coming by sea from the Burmese coast; all sea transport to be in vessels owned by the company and designed for the trade. Labor-saving machinery, both for winning the minerals, transporting the same, and final manufacture, is essential. A very important item in such a scheme would be the export trade of coal to Madras, and even other ports in the south. It is unquestionable that the profit on such a trade would go far to reduce the cost of importing the Madras ore in the return vessels. Given these conditions, and given that the steel company absorbed the profits from the mining of the minerals to the final out-turn, and carried out the scheme, with a sufficient capital and with honest, unselfish supervision, there is no doubt that remunerative success awaits the enterprise.

It may be calculated that the cost of pig iron manufactured would not exceed Rs. 40 (50s.) per ton, and the cost of finished rails and finished plates are estimated at approximately Rs. 67 and Rs. 85, girders and sections being priced intermediately.

During the year 1898 the average cost of imported rails was Rs. 81 6a. per ton. The average selling price of angle and tee section steel was not less than Rs. 6 per cwt.

A word may be said on the labor question. It is not pretended that the native of India, as a workman, can compare with a European. His strength is less, and in most cases his intelligence as a mechanic is inferior; but he has advantages which go far to compensate. He is industrious, sober, cheap and not given to the vices of trades unionism. Labor-saving devices which make up for the want of strength and want of skill are desirable, and help to bring the native on a par with the European. It may be noted that all the operations required in manufacturing steel are already in successful operation in India. At the Barakar Iron Works the local ore is regularly made into pig, and for the past six years open-hearth steel has been regularly worked at the government ordnance works in Calcutta, and more recently in the East Indian railway works at Jamalpore. Steel bars and sections of all kinds are rolled in an 18-inch mill in the ordnance works, and machinery and fittings of all kinds are made in increasing quantity at various establishments throughout India.

MESSRS. LOEWE'S MACHINE-TOOL WORKS, BERLIN.

In an article descriptive of these works, recently published in the London "Engineering" particular mention is made of the flooring, as follows:

Administration Building.—We have already in a former notice made reference to the administration building which forms the central block of the premises; this may be said to be the heart of the system, for from it emanates everything that is needed to support the life of the establishment, whilst to it again return the completed work. This department has a 10-ton traveling crane, and the floor is composed of maple planking on pine boards, with a concrete foundation.

The flooring of the whole of the buildings is worthy of special attention. In Fig. 48 annexed we give a sectional view of the

floor. The arrangement is very well indicated by the illustration. The steel joists are filled in with cement concrete, and there are also imbedded in the latter pine sleepers, to which are nailed 2-inch tongued and grooved pine planks, whilst to these planks are nailed crosswise $\frac{7}{8}$-inch hard maple boards 3 inches to 4 inches wide. Messrs. Loewe attach great importance to having a correct description of flooring for machine shops, etc. Maple wood is especially suitable for the upper surface, so much so that the planking in question was brought from the United States. Possibly an equally efficient description of wood could be obtained in Europe, although this is by no means sure, but it was found cheaper to bring the planks, of which there was sufficient to cover six acres, all the way from America, and carry them up from the seaboard to Berlin by barge. The great advantage of maple wood is that it is hard,

Fig. 48. CONSTRUCTION OF MACHINE SHOP FLOORING.

and that it is above everything tough; if chipped it does not splinter, and a heavy machine tool, with a sharp-cornered cast-iron bedplate or feet, can be dragged out with comparative ease, Its cleanliness—especially in the matter of dust—warmth, and the great ease with which it can be repaired, are also highly valuable features.

FILLETS AND ROUND CORNERS ON MODERN MACHINERY CASTINGS.*

Take some machine-tool casting, a lathe, or planer, for instance, made from twenty-five to forty years ago, and compare it with one of the same class brought out at the present time by any up-to-date concern, and what is the first point of contrast noted? You will all answer "the design." Wherein is this difference of de-

* By John M. Richardson. Read at the Pittsburg meeting (May, 1899,) of the Amercan Foundrymen's Association.

sign? It is to a great extent in the large and smoothly-rounded curves and heavy fillets everywhere present in its outline. Broadly speaking, some of these old-style castings look as though a carpenter had nailed together some sort of a foundation, and then, visiting a planing mill, had procured a quantity of moldings, and with them trimmed it very liberally wherever possible, and finally, by some flourish of the magician's wand this would-be pattern had been suddenly transformed into iron and set down in the machine shop adorned with bright red and green paint, or a combination of both, neither "a thing of beauty" nor "a joy forever." Sharp angles, fancy moldings, panels, etc., look very nice on doors, store counters and a great many kinds of furniture, but are decidedly out of place and likewise impracticable for cast iron.

I consider it of great importance to have a machine casting designed so that its exterior will present as smooth a surface as possible, and all angles and recesses of any kind provided with good, liberal fillets. The advantage of this does not lie along any one line, but everyone of the four mechanical arts, namely, drafting, pattern making, molding and machine work, which are so closely joined and interlocked as to be but four links of a great chain, of untold strength and value to mankind, are each and every one benefitted thereby. A drawing, where this matter has received attention presents a much more finished appearance, and reflects credit on the designer, for it shows that he looked ahead as far as the foundry, realizing that the design and its resultant casting bear a close relationship to one another. Many a condemned casting is such, not through any fault of the molder, but rather from bad proportioning of the metal, sharp angles, no fillets, etc., directly traceable to the drafting room.

In the pattern department fillets serve a very important purpose, and now I am treading on familiar ground, and therefore can, without hesitation, give a short outline of their merits and demerits.

A fillet is actually a pattern strengthener, aside from its foundry value, provided it is composed of a substance having some tenacity in itself, and aside from this property, it is very often a time saver also, for in fitting hubs, bosses and ribs, over curved

surfaces, or, in fact, any part fitting another, where the intersection does not lie in a plane, much time and labor is required to produce a close fit, but a firm bearing can be quite easily arrived at, having, perhaps, rather open joints here and there, and here the fillet aids the pattern maker by effectually hiding the imperfection. The molder who keeps his eyes open will notice quite a variety of materials worked into fillets on the various patterns he handles, especially if he works in a jobbing foundry. Wood, leather, lead, beeswax and putty comprise the kinds ordinarily used, and they each have their time and place, except the metallic one. A pattern being of wood has a fibrous nature, which will hold glue or any other adhesive substance, while lead has no affinity whatsoever for glue; so the only thing that can be employed is shellac or nails. I have used yards and yards of lead fillets, so can speak from experience, and I have seen old engine beds and their foundation boxes returned for repairs, where these fillets were fairly stripped away from the pattern; even the small bung-head wire nails used would not keep them anchored down.

Probably the finest fillet of all is made of wood, worked out of the solid pattern, having no feather edges whatever, but this is a very expensive kind and can only be used on the finest jobs, so in every-day practice we have to add the fillet to the pattern as a separate part. For fillets from 1 inch radius down to $\frac{1}{8}$ inch, leather is unquestionably the best and most practical material that can be used, and when properly applied will not peel up, even with the hardest usage, and requires no nailing whatever, glue being the only agent employed. Those who condemn the leather fillet for patterns probably do not understand the proper method of applying it. There is a sort of trick about it, to be sure, the keynote of success being hot water. Cover the back of the fillet with thick glue, and place it quickly on the pattern, instantly drawing a round-ended slicking tool of proper radius along its surface, bearing down hard to exude any superfluous glue, and following this with a woolen cloth wet in very hot water, to remove all pressed out by the slicker. Repeat this until not a particle of glue squeezes by the edge of the fillet, then wipe with a dry cloth. This is really not so much of an opera-

tion as it may seem from the description, and many feet of these fillets can be applied in a very short space of time.

Where it is hard to bind the leather neatly around small curves, etc., just immerse it in hot water, taking it out instantly. This renders it perfectly pliable, but it means quick work, for the thin edges will shrivel and harden at once if not immediately placed in position and burnished down as previously described. A leather fillet put on properly, with strong glue, can only be removed when dry by main force, and will then come off with fibers of the wood adhering to it, and sometimes the leather itself will keep breaking—it takes so much force to make it let go. Light patterns are strengthened by them to such an extent that nails are frequently unnecessary. Beeswax is all right for very small fillets and for finishing out where leather ones come together at the top edge of a rib when the curve is very small, and for many other places. The wax is prepared by being put in a cylinder, having holes of varying diameter in one end. This is warmed and the wax forced through with a plunger, and then applied with a warm slicking tool of the right radius. If used too cold the fillet will not adhere firmly to the wood. In fact, it is hard to lay wax fillets satisfactorily in a cold room, for both pattern and wax are chilled to commence with, and the heated iron bearing on the top surface of the fillet only makes it difficult to communicate the heat evenly enough through the whole mass to secure a firm contact with the wood, and after the pattern has seen constant use in the foundry the wax will peel up badly; also it is not a durable substance for a fillet if sunshine or heat of any kind strikes it to any extent.

Putty has always been used in great quantities in pattern making, and probably always will be, on account of its cheapness. Undoubtedly more feet of fillet can be applied in a given time with this substance for a given amount, taking both the material and labor into consideration, than with anything else; but it is only adapted to cheap work, and not for standard patterns, as it is soft, easily dented, marred or bruised, besides imparting no element of strength whatever to the work. In some places plaster of paris is added to it, to increase its durability, but when

this is done it must be used immediately after mixing. Black putty is also frequently used. This is nothing but common putty mixed with lampblack, and is employed only on cheap work, having but one coat of shellac, this being applied after the sand papering, thus comparing in color with the blacking on the pattern, and saving a second coat.

When fillets are called for having a radius above one inch, then they must be worked out of wood, and this should be done after gluing to the pattern, not before, in order to have the feather edge adhere as firmly to the work as possible. It is almost impossible not to have the edge curl away if cut out first and then fastened to the pattern, even if the precaution is taken to have the angle of the fillet made slightly greater than that of the corner it fits, in order to cause a binding of the edges.

A mold of any considerable size can be made more safely, quickly and easily and with a minimum of labor, where these points have been considered in the design and carefully followed out in the pattern and with far more chances for perfect casting, as the danger of cracks in shrinking have been eliminated. How many castings are spoiled by having some slender part joined to a heavier one, with no fillet where they come together, thus causing a crack by the shrinkage strain at the junction, it would be hard to determine.

A pattern when heavily rounded wherever possible will certainly leave the sand very much easier and with less danger of breaking the mold, thus saving labor in patching and mending, which is always a form of dead loss to the proprietor on day work, or to the molder on job work, besides being a great vexation to the workman himself.

I would go so far to say that every edge of a pattern, except on surfaces to be machined later, should be rounded, even if the radius of curvature is so small on some light work that it can be done entirely with sandpaper, and on brackets, ribs, heading, etc., it is much more satisfactory when one gets accustomed to it to have the edges terminate in a semi-circular section rather than flat with the two corners somewhat rounded.

This rounding of outside surfaces is necessarily on the pattern

itself, but there is something else frequently not on the pattern that is expected just as much to be on the casting, and that is the fillets. How many molders can testify to getting patterns with chalk mark all around every corner and rib, and this injunction in two words, "cut fillets," also marked in chalk somewhere on the surface. Once in a great while a case occurs where this is justifiable, but it should be rare. A molder does not profess to be a sculptor, and when he is forced to carve out fillets in the sand who can blame him if, instead of being the radius of a circle they prove to be the hypothenuse of a right-angled triangle. Then, too, there are often places in the mold where it is very difficult to do this, without dropping sand down into parts where it is hard work to remove it, and the result will be an imperfect casting.

Another thing I wish to mention in this connection, although it does not show on the casting except by a fin which must be clipped off before leaving the foundry, is still in the nature of a fillet. When a core is placed in position horizontally, and the cope closed down, the impression made by the core print where it joins the main pattern is liable to be crushed where it enters the body of the mold, unless the molder shaves off the corner so that, at this juncture, the core does not quite touch the edge. This shaving process is done as a foundry precaution, and varies from a slight amount on small work to perhaps $\frac{1}{8}$ inch or more clearance all around where the core enters the mold, this gradually tapering off to the size made by the core print.

The fact of cores coming in the interior of a casting, and the places made by them being entirely out of sight, is a sort of "will-o'-the wisp" to some, who imagine that fillets are unnecessary because they do not show. This is a great error. They are just as much needed here as elsewhere to strengthen the casting, and to help resist shrinkage strains, and should be put in of a size proportioned to the casting to which they belong, but need not be made excessively large, as they frequently are on the outside of a pattern, simply for the graceful effect, for these are not seen. Their place is in the core box, and not as a production of the coremaker's trowel or file. It will sometimes happen that a

fillet is called for on what is the top, or open end, of a core box, thus making it impracticable for the patternmaker to provide for it. In such cases the coremaker ought not to object to making it in the sand, and, as it comes within the casting, and is out of sight a plain, flat damper is all that is required, and the fillets already in the core box will be a guide for the size. Another case showing the utility of heavily rounded outlines and fillets on castings is when they undergo the cleaning process, and they will also pickle and peel more freely, as there are no sharp corners for the sand to stick into, and thus time and the edges of the cold chisels are saved.

As we reach the machine shop, the man who snags the casting finds no sharp corners full of sand to be scraped out with old files, and as he scours his work down with the coarse emery brick preparatory to painting, he can do much more effective service, for as the stone becomes rounded on the corners with use, it will still clean the large fillets, whereas with sharp corners it could not, and finally, when the iron filler is applied to one of these smoothly outlined castings, it can be sand papered down easily and quickly, so that, after the painting is completed, the effect, when properly done, is almost like velvet.

IMMENSE ELECTRICAL DREDGE.

Increasing interest in the subject of electrical power with reference to its adaptability to vessels of various kinds insures widespread attention to everything having reference to an electrical dredge recently constructed for use on the Volga river, Russia. Distinctly unique, it marks unquestionably a step in advance in the progress of this form of power. The designer is Mr. Lindon W. Bates, an American engineer, who designed the dredge *Beta*, built some time ago for the United States Government, and which has already made a record of 7,800 cubic yards of material per hour. The dredge was constructed by the Societe Cockerill of Belgium, one of the leading shipbuilding establishments on the continent. Trials were held near Antwerp which proved highly gratifying to both designer and builders.

The Volga dredge is constructed really in two parts, as her beam is limited by the width of the canal system Marie, through which she must pass from the Baltic to reach the Volga. The double dredge can be operated as a whole, making a bottom cut 62 feet wide, or each half can be operated separately. Each half measures 216 feet by 31½ feet wide and 9 feet deep. At light draught the hull draws 4 feet; the working draught is 8 inches greater. The dredge is electrically self-propelling and controllable, the electric installation of each half consisting of a 600-kilowatt generator directly connected to a fore-and-aft triple-expansion engine. The generator supplies two stern motors and two bow motors, each of 125 horsepower, driving 4-foot screw propellers. The generators also supply power to the two 30-horsepower motors mounted in the distributing pontoon and arranged to control the position of the pontoon line as required by operations. Lighting is done from a separate installation. Control of all motors is centralized in the pilot house. Quarters are provided for the crew and Government engineers on each hull. The pipe pontoons are elliptical air jackets, reversible and not easily affected by wind, waves or currents. Metal joints are used, as these do not obstruct the discharge stream so much as rubber connections. Each pair of compound cutter engines works four cutters. Each main-pump engine can develop 1,500 indicated horsepower. The tender is a stern-wheel steamer with a speed of 10 knots an hour. The whole is manifestly much smaller than those used on the Mississippi, more effective, and can take care of more bars or miles of river than any plant heretofore devised.

A Series of Tests.

All parts of the dredge were subjected to searching trials prior to the departure of the plant for St. Petersburg. One set of tests for one-half of the dredge was conducted at Drygoten, Belgium, on a testing ground provided by the Belgian government, in a basin of about 40 acres; the other was conducted at Steendorp, on a bar in the River Scheldt, about 10 miles above Antwerp. Unofficial trial No. 1, at Drygoten, was for the purpose of ascertaining the precision with which a given stratum could be taken,

and it was found possible by raising and lowering the cutters to take a stratum of thickness up to 7 feet. The dredge advanced at a speed proportioned to the depth of the cut, fast for a shallow excavation, more slowly for a deep one. One test for an average cutting of 2 feet 4 inches resulted as follows: Distance run, 1,200 feet; time, 1 hour and 16 minutes; advance per minute, 15.78 feet; average cut, 2.38 feet; rate per hour, 2,590 cubic yards. The material was of fine, compact sand and clay. This had been formerly farm land below the plane of cultivation. The cultivated surface had been previously removed for the construction of levees. Two weeks later, the first official Russian trial was made in a cut parallel to the former, with higher steam, more pump revolutions, and a crew which had become familiar with the mechanism. In this trial, the result was as follows: Distance run, 1,000 feet; time, 37⅛ minutes; advance per minute, 26.8 feet; average cut, 2.44 feet; rate per hour, 4,524 cubic yards. The material in this cut was favorable, half of it being a loose sand, the other half a compact sand mixed with clay.

Trials of the other half of the dredge were conducted on a large bar at Steendorp composed of very fine sand. Some cuts were along hard, packed material; others were in material relatively loose. None of the material on the Scheldt is of so favorable a character as the coarse, loose sand met with in the cross-over bars of the Volga and Mississippi rivers. Preliminary to the official trials, two prolonged tests were made at Steendorp to determine methods of sounding and measurement. The first test showed an average rate of advance per minute of 10.13 feet; average cut, 5.66 feet; rate per hour, 3,824 cubic yards. In another place, the advance per minute was 9.09 feet; average cut, 4.62 feet; rate per hour, 2,803 cubic yards. It was observed that on account of the hardness of the face, the cutters were not powered sufficiently high to supply the full carrying capacity of the pumps. The second official test, conducted at Steendorp, resulted as follows: Distance run, 2,129.5 feet; time, 3 hours; advance per minute, 11.83 feet; average cut, 3.52 feet; rate per hour, 2,860 cubic yards. Material in this case was fine, compact sand.

All tests were conducted with 700 feet of discharge pipe. All measurements were in excavation, and, to determine the capacity, upwards of 5,500 soundings were taken. The Mississippi measurements were barge measurements, and to make comparison with the maximum capacity rate achieved by the *Beta*, it is necessary to double the official test No. 1 (4,524 cubic yards) of the half Volga and add 15 per cent., or 10,404 cubic yards, which is 30 per cent. higher than any previous record. At the termination of the trials, it was officially considered that each half of the dredge would be conservatively rated as having an hourly capacity of 2,700 cubic meters, or about 3,500 cubic yards; a total for the whole plant of 7,000 cubic yards per hour. It was also demonstrated that working on a cross-over bar, with a current velocity of 3 to 4 knots per hour, the dredge could be maneuvered with facility with but one line (ahead), thus doing away with half a dozen lines heretofore necessary for holding and maneuvering. As the machine is self-propelling and self-controlling in the current, the electric features have manifestly added enormously to the effective use of the dredge and have minimized all possible interference with commerce.—"Marine Review."

THE OUTLOOK IN THE AMERICAN IRON INDUSTRY.

A rise of 100 per cent. in six months in the price of a commodity so universally used as iron is calculated to startle the world. It requires little sagacity to see that if present values are to be maintained for any length of time, a new basis of all industrial operations is rendered necessary. Will it last? How can it last? Assuming that 1898 prices netted cost to the makers, it would seem to follow that there is 100 per cent. profit in the manufacture to-day. Millions of capital are eagerly seeking investment where one tenth of that return can be assured. Why will not that capital rush in, start the idle furnaces and mills, build new ones, and quickly break down the markets by overproduction? Again, will not new undertakings be checked by the high cost of structural steel, machinery, rolling stock, electrical equipment and the like, so that the great demand will soon

begin to fall off, and the makers find themselves with more iron than customers?

Questions like these are universally asked by those who produce as well as by those who consume. The answer reaches far into economics—labor conditions, relations with foreign nations, transportation facilities, the physical limitations of mines, waterways, etc., the staying quality of the farmers and laboring masses in their power to buy needed things and pay good prices for them, the rapid increase of gold coinage in the world, and last, but not least, the capricious but powerful factor in all commerce and industry—human nature.

The facts of the rise in prices are fresh in all minds. In the first week in December, 1898, the larger interests in Alabama felt that the better demand warranted adding 25 cents per ton to the price of $7.00, then prevailing for No. 2 foundry pig iron f. o. b. cars Birmingham. It is a somewhat curious fact that, while Alabama produces less than a tenth of the pig iron made in the United States, it is her admitted prerogative to fix prices for the whole market. This is due, doubtless, to two causes. It is the cheapest center of production of raw iron in the world, and its product reaches nearly all consuming markets of the United States, and even of Europe, on more nearly equal terms than that of any other district.

There was not much confidence in the improvement at first. There had been several false starts since the Baring failure in 1890 and the memorable panic of 1893, and nothing was more deeply fixed in the minds of producers and consumers alike than that the era of low prices was here to stay. Here and there a man had a memory and used it. But, for the most part, furnaces and mills sold freely on the first slight advance. When the price was up fifty cents a ton on pig iron and a dollar on steel billets and bars, furnace and mill owners joyfully took heavy contracts. When another dollar was added, along in January, many of the strongest and most conservative concerns in the United States booked their output for three, six, and even nine months ahead. At this writing (September) tens of thousands of tons of material are still going forward on these low-priced contracts. And to

the honor of the trade be it said that, almost universally, the fulfillment of these low-priced orders is given preference over newer and highly profitable business. Here and there an unscrupulous concern has found the temptation to side track the cheap business too great to resist, but these are rare exceptions to the general rule of good faith and business honesty.

The incredulity of the trade as to the genuineness and extent of the improvement had one conspicuous illustration in the highest quarters. The Lake Superior ore interests are counted the corner-stone of the American iron and steel industry. The owners and agents centering in Cleveland, Pittsburg, Youngstown and Chicago, thought prudence dictated a conservative policy, and opened their books in February at agreed prices, averaging scarcely 25 cents a ton above the very low range of 1898. The ore was snapped up almost in a day, and before the bewildered sellers could tell what had happened, the vast product of all the Lake Superior ranges was sold for deliveries extending to July 1st, 1900. Stockholders of mines and other critics, wise after the facts, have wondered at a policy so very conservative towards the mine owner, and so highly liberal to the furnaces. In the light of subsequent events, it was a huge mistake. But it must be remembered and emphasized that as late as March, only a man here and there in the whole trade showed, by his acts, his faith in the large improvement which was so rapidly to follow.

The following table will show the change that has taken place in prices of a few of the leading products in different markets of the United States:

Pig Iron.	Sept. 6, 1899.	Aug. 23, 1899.	Aug. 2, 1899.	Aug. 31, 1898.
Foundry pig, No. 2, standard, Philadelphia	$22.00	$20.75	$20.25	$10.50
Foundry pig, No. 2, southern Cincinnati	19.25	18.50	18.00	9.50
Foundry pig, No. 2, local, Chicago	21.00	20.50	20.00	11.00
Bessemer pig, Pittsburg	23.25	22.50	21.25	10.00
Gray forge, Pittsburg	19.50	18.50	17.75	9.35
Lake Superior charcoal, Chicago	24.00	23.00	22.00	11.50
Billets, Rails, Etc.				
Steel billets, Pittsburg	37.00	36.00	34.00	16.00
Steel billets, Philadelphia	39.00	38.00	36.00	17.75
Steel billets, Chicago	...	36.80	36.80	17.00

Billets, Rails, Etc.	Sept. 6, 1899.	Aug. 23, 1899.	Aug. 2, 1899.	Aug. 31, 1898.
Wire rods, Pittsburg	44.00	44.00	43.00	22.00
Steel rails, heavy eastern mill	32.00	32.00	30.00	18.00
Spikes, tidewater	2.35	2.30	2.00	1.40
Splice bars, tidewater	2.05	2.00	1.90	1.05

Without going into a tedious array of statistics, a few leading facts and figures are necessary to an intelligent knowledge of the problems outlined in the first paragraph of this necessarily general sketch. The history of the iron trade in the United States shows a persistent tendency to double consumption and production every decade. When the figures were small, in the years preceding and immediately following the civil war, it seemed no great thing to double in ten years. But when the statistics have grown to huge proportions, leading all the countries of the world, it seems like a geometrical ratio impossible to maintain. But if it is not made in 1900, it will only be because of physical limitations placed on production, not because the demand is wanting. The following figures will help illuminate the subject:

Pig-Iron Production of the United States by Decades.

	Gross Tons.		Gross Tons.
1859	750,559	1880	3,835,191
1860	821,223	1889	7,603,638
1869	1,711,285	1890	9,202,703
1870	1,665,178	1898	11,773,934
1879	2,741,852	1899 (estimated)	13,000,000

Stocks of pig iron in furnace and warrant yards in the United States in 1897 exceeded 1,000,000 tons. September 1, 1899, they had been reduced to about 160,000 tons, as the following figures show:

April 1, 1897,	1,092,113
April 1, 1898,	814,951
April 1, 1899,	302,628
Sept. 1, 1899 (estimated),	160,000

It appears from Mr. Swank's tables that the consumption of pig iron in the United States in 1898 averaged a little over 1,000,000 tons per month. In 1899 consumption is limited closely to the output and may therefore be estimated at 13,000,000 to 13,500,000 gross tons for the year.

Going back now to the question "Will it last?" Frankly, it must be admitted no man knows. It is not given to mortals to unlock the future. War, famine, pestilence, Bryanism, may intervene and upset all calculations. But the wise man faces the facts as they are before him, and builds his judgment on these, discarding optimism, pessimism, preconceived theories, and even tradition. There were never better settled or apparently sounder commercial traditions in the past than that dollar wheat, ten-cent cotton, and ten-dollar pig iron (at Birmingham) marked the bottom limits in the great staples; but we became familiar with values scarcely more than half these, and men lived and prospered.

The simplest and largest fact in the present situation is a demand greater than the supply. What makes the demand? What limits the supply? The demand is great because seventy millions of people have pinched and economized for six or eight years, and now are quite able to buy, and what is of more consequence are in a mood to buy. They have made the old stove answer, worn out the harvester and threshing machine, postponed the building of the county bridge, got along with the old stationary engine or lathe, put off the purchase of needed rolling stock for the railroad, hesitated to try conclusions with England in the building of ships, and generally have waited for the return of what is known as "good times." Now they want to replenish, from the sad iron to the locomotive. Will they stop because prices advance? No, they will not. Here enters the element of human nature. Confidence breeds confidence. Distrust feeds on itself. Two years ago the great railroads of the United States could have renewed much needed equipment at about half the cost that to-day they do not hesitate to pay. Did they do it? It is notorious that the richest hesitated most. An amusing illustration is the case of a master mechanic of a great road whose requisitions underwent the usual cutting in two in the middle when they reached the management. Among the track and shop supplies needed was a large belt for an engine. When it came it had suffered the usual pruning, and was just half long enough to reach. The writer will not soon forget

an effort, in the summer of 1897, to find a buyer in New York for 100,000 tons of Alabama pig iron which a large interest was willing to close out at six dollars a gross ton, duly stored in a warrant yard—a price unprecedented in the history of the world. Not one of the great banking houses of capitalists dare face the perils connected with such a proposition, though money was ruling at three per cent., and nearly free storage on the material was guaranteed. To-day almost any bank in New York would lend fifteen dollars a ton on it, and scarcely ask a question.

Buying, therefore, will not stop because prices are up. The railroads must have enormous additions to equipment, or lose the great harvest of profitable traffic. The millions of farmers will buy their agricultural machinery, stoves, carriages and pianos, because crops have been good for three years, fetch good prices, the mortgages are paid off, and there is money in bank. Electrical equipment will not stop while street railways and lighting companies make large earnings, merely because dynamos and rails are dearer. Cities and towns will put in needed water and gas pipe without much regard to whether the cost is $18.00 or $28.00 a ton.

It is perfectly true that some new enterprises, that otherwise would take shape, are deferred because cost is found to exceed engineers' estimates. But this builds a reserve demand that will come in to support the market in the future. In high steel buildings, in large cities, for example, there is a distinct limit to prices that may be paid for materials without bringing the cost to a point beyond earning ability. The merchant marine can not be built up as rapidly from American shipyards on $28.00 steel as on $16.00 steel. But these are but eddies in the main current.

The real factor in lowering prices will be in increased production, not diminished demand. How fast can the output of the furnaces be increased? I say not over fifteen to eighteen per cent. per annum. There was incredulity in as high quarters as Mr. Swank, Secretary of the American Iron and Steel Association, when this prediction was made early in the year. For were there not a couple of hundred idle blast furnaces in the

country ready to blow in the moment profitable prices were reached? Would American capital or energy hesitate where the reward was so great?

It may be profitable to analyze the factors which operate to restrict profitable production. In a situation like the present they are clearly revealed, and many fine theories are upset by common physical facts. Few people, who have not actually run a blast furnace realize what it means to fill the capacious maw of one of those monsters with raw material. A stack of 200-tons daily capacity, running on 50 per cent. ore, must have delivered to it each day something more than 400 tons of ore, 250 to 300 tons of coke, according to the character of the metal required, and over 100 tons of limestone, besides sand, coal and minor supplies—say 900 tons raw materials. Add the 200 tons of pig-iron product shipped out, and we have a daily freight movement of 1,100 tons, taking no note of the disposition of the slag. This is 55 carloads of 20 tons each. The mining of the ore requires the labor of 150 to 300 men, according to location; the coal mining, coke making, quarrying of limestone and transportation at least 300 more. The furnace itself employs about 150 or more hands. It will be seen, therefore, that starting up a furnace of ordinary capacity calls immediately for the labor, from first to last, of nearly a thousand men; for the use of at least a thousand railway cars and many locomotives; for perhaps several steamers and vessels on the lakes; for capital, from the mines to the pig iron, of one to two millions of dollars, and last, but not least, for a high order of managing ability, the scarcest of all scarce commodities, in times like these.

To use a concrete illustration, the Tonawanda Iron & Steel Co., located near Buffalo, operating two furnaces only, must unload at its docks one good-sized ship load of ore every day during the entire season of lake navigation, or fail to get down its needed supply. Another striking evidence of what it means to bring down the ore for the furnaces now running which depend on Lake Superior mines may be witnessed any day on Detroit River, where the loaded steamers and sailing vessels down, and the light craft up, crowd so close upon each other as almost to touch.

Still another illustration, at hand as I write, is that of a small charcoal furnace on the lower lakes, needing about 80 tons a day, but unable to start because transportation could not be had for it. To add 1,000,000 tons, or say 10 per cent. to production, means the organizing, equipping, and starting of twenty such operations as described in the preceding paragraph.

The easy theory, therefore, that production can be turned on, as from a faucet, when profits are high, does not fit the facts. It is needless to say that every nerve will be strained to get into operation at the earliest moment the few existing idle plants, but those who base their calculations on an increase of not over 12 to 15 per cent. per annum in the next two or three years, will not go far astray.

It has not escaped notice that in all the present excitement, little is heard of organizing companies to build new plants. Each of the great consolidations is planning additions to capacity, but there are few schemes to develop idle property, as was the case about 1890. There are reasons for this. The building of furnaces to sell town lots was generally disastrous. The impression is still abroad that there is a large reserve idle capacity. But the main factor in restraint is that, under present conditions, it would require at least a year and a-half to build a good modern plant; the cost would be 50 per cent. greater than a year ago—and who knows where iron would be when the furnace was ready to start? The wisdom of the policy of building and enlarging in the bad times, followed for many years by Krupp and Carnegie, is demonstrated in a period like this.

What of the export trade? It is generally believed that this new factor is the all important one in sustaining American markets. Taking the iron and steel manufacture as a whole, I believe this to be true. But so far as ores, pig iron, and even steel billets are concerned, the movements have never reached 5 per cent. of the product of the United States, and probably will not for years to come. Radical changes in the freight and labor situations must occur before America can capture English and European markets with crude iron. She is shipping liberally, it

is true, and will continue to ship, for prices in Europe will always be regulated pretty closely by those in the United States. But it is in the finished forms where American victories will be won, as they are now being won. In locomotives, wood and iron-working machinery, agricultural machinery, nails, wire, bicyles and a hundred other lines, American inventive genius, great productive capacity, modernized plants, superior business organization, etc., will maintain and doubtless increase the great total of $80,000,000 reached last year in her iron and steel exports. The effect of this great and growing foreign demand is sensibly felt in every department of the trade.

The belief is widespread that exports from the United States must suffer a sharp check, if not come to a full stop, unless prices in America recede. This is a natural, but not well grounded, view. It assumes that the markets of the rest of the world go their way irrespective of what the United States does. That was formerly the case, but it is so no longer. The world is now knit closely together in its industrial and commercial as well as its financial fabric. Influences that affect one nation are soon felt by the others. England and Germany were in the midst of industrial prosperity two years before it was felt in America, but now that she has responded, the added stimulus is felt over there. We think it phenomenal that the mills and furnaces throughout the United States should have their product booked half through next year, but in Germany and Belgium they are already booked all through the year 1900. The great Krupp works at Essen, employing thirty thousand men, are filled with orders until 1901. Germany has nearly overtaken Great Britain in pig-iron product, but is nevertheless importing largely from both England and America to supply her deficiency. Great Britain shows a slackening in her shipbuilding industry, but her export trade in iron is again growing and all her lesser industries are exceedingly active. Prices of iron and steel have risen there almost as rapidly as in the United States. Middlesboro pig that sold last year for 43 shillings has reached 75 shillings and is now a little under 70.

The fact is the great industrial awakening is worldwide. China, India, South Africa, the Philippines, Japan, Russia, and the new

island possessions nearer to the United States are full of projects for improvement. They have caught the renaissance spirit. The beginnings are small, but they suggest immense future possibilities. They want steam railways, electric lines, electric lighting, water-works, locomotives, machinery, bridges, etc., and it scarcely seems probable that having felt some of the benefits of modern progress, they will decide to turn back. America has shown her ability to compete with the other industrial nations for this trade, and will continue to get it in increasing quantity.

The world's consumption of iron grows in geometrical ratio. In 1740 it did not amount to one pound for each inhabitant. In 1856 it was about 17 pounds per capita. In 1890 it was 35 pounds per capita. In 1900 it will be probably 60 pounds per capita. The following table of consumption in the different countries proves the claim of iron to be the barometer of civilization:

	1856.	1890.
Great Britain, pounds, ...	144	250
United States, pounds, . . .	117	300
France, pounds, ...	60	175
Germany, pounds, ...	50	175
Belgium, pounds, ...	70	175
Sweden, pounds, ...	30	100
All the rest, say, pounds, . . .	6	12

In this connection the growth of the world's production of pig iron is interesting. In round numbers, this has been as follows:

In 1856, gross tons, ...	6,600,000
In 1867, gross tons, ...	9,300,000
In 1878, gross tons, ...	14,100,000
In 1889, gross tons, ...	25,000,000
In 1890, gross tons, ...	26,500,000
In 1900, gross tons, estimated, . .	35,000,000

Of the last enormous total there is good reason now to believe that the United States will supply 40 per cent.

A word as to the new level of prices. It is too high, of course, to be permanently maintained. It is too high for the lasting good of this great industry. But we must not be misled by mak-

ing false comparisons. The conditions reached in the lean years following the panic were abnormal, not natural. Iron was forced to $6 a ton at Birmingham on wages of 90 cents a day for twelve hours' work; on transportation rates that did not return the railroad's cost, and on destruction of royalties or value of the ore and coal in the ground. The same was practically true in the Lake Superior District. It was simply a struggle for life. Values of great properties shrunk from millions to hundreds of thousands. Labor and capital fled to other fields. America learned great and valuable lessons during this trying experience, among others, how to produce iron more cheaply than has ever been done in the history of the world. Perhaps in the end the experience may prove to have been a blessing. But we must not make the error of supposing that those were normal conditions, and that when we have escaped from them we are on an artificial basis. A sound view is that we are nearer normal conditions to-day than we were when 100,000 tons of $6 pig iron went begging for a buyer in New York. A cent a pound for the best pig iron in the world should not, after all, paralyze the faculties of reasonable persons.

It should not be forgotten that the cost of iron resolves itself substantially into three things: labor, transportation and royalties, or the value of the material in the ground. Labor, the largest item, is up 25 to 40 per cent. in iron making. It is not yet too high for the good of the country. Transportation is up about as much, but who shall say the stockholders of the railroads and steamship lines are not entitled to a few dividends after years of waiting? It is now possible to credit ore and coal mines with something for the materials in the ground. But is it a violent assumption that the great iron and coal deposits of the United States, which are usually counted the foundation of wealth in an industrial nation, are actually worth something and should return a profit to their owners on material mined out? If these points are conceded, the legitimate cost of pig iron in the United States is at least 33 per cent. above the low level to which it was forced in the years from 1895 to 1898. The manufacturer's profit, if any, must be added to this. It is some satisfaction to know

also that cost is rising proportionately in other parts of the world. In great Britain and Germany the increase varies from $2 to $4 per ton, according to kind of metal and locality where it is made. This is due mainly to the steady rise in the price of coke, although ores have advanced and are in short supply.

Cautious investors as well as manufacturers quite naturally look forward to the time when collapse will again take the place of boom, and prices will drop below cost of production. Who shall stand against that day? The strong, who expect to survive, are taking extraordinary measures to equip themselves for whatever may happen. The huge consolidations—at least those newly organized—are free from bonded debts, with large provisions for working capital. Some of them, indeed, are lenders of money in the street. Nearly all have strengthened themselves by ownership of ore mines, coal mines, coke ovens, and even transportation lines, so that they are independent "from the ground up." If the time ever again comes for a fight for existence, it will be between giants indeed, and no other nation can resist American inroads. But every observing man has noted, in the instructive years of the past decade, the wonderful tenacity of life of small plants well located and economically managed. Another thing that has not escaped notice is that in the "survival" struggle, there is a marked tendency to equalize conditions in all the different districts. It is a fact capable of demonstration that the best returns on capital during the lean years were not from the great concerns in the most favored locations (barring one or two exceptions), but from certain smaller operations located in districts not usually spoken of as the cheap centers of production. It is a safe assumption, therefore, that, whatever lengths the consolidation movement may extend to, there will be plenty of strong undertakings on the outside that will keep the industry on the sound footing of free competition.—Archer Brown, in "The Engineering Magazine."

"THE AGE OF NICKEL-STEEL."

During the year 1890 Hon. Benjamin F. Tracy, then Secretary of the United States Navy, received, in confidence, the informa-

tion that Schneider & Co., of Le Creusot, France, had invented a new armor plate which contained about 3½ per cent. nickel. With characteristic American eagerness to procure the very best armor for the protection of its warships, and with the view of making a thorough test of the best plate produced in other countries, an order was placed in Europe for three plates, one from England and two from France. The one from England was of the same character and composition as was then specified by the Admiralty for warships. One of those ordered from France was of plain steel and one was nickel-steel. These three plates were in due time set up side by side at the Annapolis testing grounds and fired at by a 6½ inch gun at a distance of 50 feet. The British plate was broken in pieces, the French plate was badly cracked, while the nickel-steel plate suffered comparatively little injury.

This test proved very conclusively that the nickel-steel plate was what the United States Government desired for the protection of its warships. In fact, it was not only a revelation to the civilized nations of the earth, but caused a complete revolution in the manufacture of armor plate. Congress immediately voted $1,000,000 for the purchase of nickel, and the Department changed all its contracts for armor plate and specified nickel-steel plates. Thus it was that in the year 1890 we entered upon the "age of nickel-steel," through the initiative of a citizen of France. Its development was due to America's combining with it the Harvey process for face hardening nickel-steel armor plate.

The nickel-steel of commerce as used for the production of armor plate, driving and piston rods, tires, axles, propeller shafts, &c., is made by the open-hearth process, and generally contains 3 to 3½ per cent. of nickel. The introduction of this small amount of nickel in steel gives us an increase in elastic limit of 75 per cent. and in tensile strength an increase of 30 per cent. over simple steel, without any impairment of the elongation or the reduction of area. A defect in a nickel-steel forging will not develop, and does not necessarily mean that the forging will fracture at that point, as would undoubtedly be the case in simple steel.

These facts then further demonstrate to us that in the production of nickel-steel for various commercial purposes we have a thoroughly reliable metal which is absolutely free from the treacherous brittleness due to crystallization so characteristic in simple steel.

When pure commercial nickel some years ago was selling around $7 per pound we were compelled to admit that the field did not look very inviting for manufacturers to experiment. At the present time, however, with nickel selling between 30 and 40 cents per pound, the production of nickel-steel is growing to enormous proportions, owing to its many virtues, which the modern manufacturer is compelled to recognize. While the first cost is somewhat more than that of simple steel, the additional extra cost of 3 or 3½ per cent. nickel at say 40 cents per pound is very insignificant, when it is considered that nickel-steel will outlast simple steel several times in the general wear and tear.

In the production of nickel-steel by the crucible process numerous interesting and valuable results have been obtained. It has been my experience that for every per cent. increase in nickel contents there is a corresponding increase in the hardness of the metal, and a decrease in its ability to take a temper, until we reach 16 to 18 per cent. nickel. At this point the metal becomes exceedingly hard and extremely difficult to machine, but it can be worked, when heated, into almost any desired form by rolling, or forging, in the ordinary manner as practiced in manipulating simple steel. By continuing to increase the nickel contents beyond the point mentioned the material becomes softer, and at 25 per cent. nickel we have an exceedingly soft, ductile alloy which cannot be hardened in water, but is capable of being pressed, bent, rolled or drawn cold into various forms for bicycle spokes and parts, spoons, saddlery, hardware, etc.

At the extreme hardness of 16 to 18 per cent. nickel extraordinary fine table knives may be produced, by simply forging to shape and continuing with light hammer blows until the heat disappears from the blade. After the knives become cold it will be found that the blades are very elastic, free from the danger of breaking when bent, like simple steel blades hardened and tem-

pered in the usual manner. The knives when polished assume a most beautiful luster, tinged with a delicate blue so prized by the steel maker.

Crucible steel not containing over 5 per cent. nickel in combination with various percentages of carbon makes an extremely tough, tenacious product, suitable for edge tools, springs, &c. Experiments, however, in this direction have led me to prefer a nickel content of from 2½ to 4½ per cent., as I find a very marked decrease in the ability of the product to take a satisfactory temper beyond the 4½ per cent. limit. When kept within the limits mentioned, and when proper care is exercised in its manufacture, the product is an ideal tool steel of wonderful endurance, capable of great execution after forging to shape and hardening and tempering in the usual manner.

Since nickel-steel chills rapidly it is necessary that the crucibles be removed from the melting fires at a good, clear heat and that casting be done immediately. It would be well to bear in mind that, owing to the great affinity existing between nickel and oxygen, a suitable flux must be used in order to eliminate the latter and to prevent the nickel from oxidizing during process of fusion. Otherwise the product will be a mass of spongy, seamy material unfit for commercial purposes.

The addition of nickel to simple steel appears to admit of a higher degree of heat in forging, rolling, &c., without danger of segregation. A very good demonstration of this fact can be had by introducing a few ounces of nickel to a mixture of air or self-hardening steel, when it will be found that the material may be forged at a somewhat higher heat than is customary, and that the product now combines toughness with hardness, which is absolutely essential in the production of a first-class self-hardening steel.

Extraordinarily fine watch main springs, 0.008-inch in diameter and 0.115-inch in width, containing 3 per cent. nickel with carbon about 1 per cent., have been produced that could be wound and rewound upon a small mandrel in opposite directions a number of times without any impairment to the springs, and surpassing in elasticity the best cast simple steel. Excel-

lent nickel-steel pens, that glide over the paper when writing as though they were lubricated, have been made from steel with a nickel content of 4 per cent., and as the consumption of cold-rolled simple steel for pen points is nearly 1,000 tons per year a valuable market awaits the former product on account of its superiority over simple steel. Cold-drawn wire containing from 20 to 30 per cent. of nickel made into bicycle spokes shows a wonderful degree of toughness, combined with the ability to swage and thread perfectly. Wire of this description has a tensile strength of about 190,000 pounds, and an elastic limit of about 130,000 pounds, and may be tied into a knot cold without fracture.—H. J. Williams, in "Iron Age."

THE WIRELESS-TELEGRAPH TESTS IN THE U. S. NAVY.

The "Electrical World and Engineer" of November 11th notices recent experiments of this system in the following paragraph:

The practical tests of the Marconi system of wireless telegraphy, which have been conducted during the past two weeks on United States warships, and which tests were referred to in these columns last week, were concluded on November 1. At the Highlands of the Navesink a station was established, and placed in charge of Lieutenant Blish, for the purpose of interrupting messages sent between the *New York* and *Massachusetts*. The interference apparatus on the Highlands consisted of a 150-foot vertical wire triced up on a pole. To the foot of this wire a Marconi instrument was attached, so that when a message was sent from the Navesink station it would interrupt any messages being sent at the same time within the radial circumferences of the electrical wave produced by the sending of the message. The two warships left their anchorage off West Thirty-fifth street on Monday forenoon and went down the bay, where the tests were begun. On the way messages were exchanged successfully and to the expressed satisfaction of the commission. When the warships arrived off Navesink the *New York* anchored and the *Massachusetts* steamed out to sea thirty-six miles, for

the purpose of making long-distance tests, and also to try the extent of the interference the apparatus at Navesink would exercise while messages were being exchanged between the warships. All the time the *Massachusetts* was making her way to sea messages were exchanged between her and the *New York* at intervals of ten minutes, and interference messages were sent by the operator at Navesink at longer intervals. The interference messages were successful, and rendered the messages between the warships unintelligible. At a distance of thirty-six miles the messages sent by the *New York* to the *Massachusetts* failed to carry, and the battleship came back and anchored a few hundred yards from the *New York*. During the day forty-five messages were sent by the *New York*. Of these twenty-three were received and five were interrupted. The storm that came up on Monday night disabled the wireless-telegraphy apparatus, and on Tuesday afternoon the *New York* and *Massachusetts* were compelled by the rough weather to come inside Sandy Hook. While going out to sea Wednesday morning a man fell overboard from the *Massachusetts*, and the news was telegraphed wirelessly to the *New York* ten minutes before it could be wigwagged by the signal man. The man was rescued by a cutter. The tests were continued all day and were pronounced satisfactory. Before beginning the experiments Mr. Marconi wrote to the commission, explaining that he had not received sufficient notice to enable him to get his instruments in shape. He added that he had an instrument which would render interference practically impossible.

We append to the above the following from the "Army and Navy Register:"

The conclusions and recommendations of the Naval Board on the experiments with wireless telegraphy are as follows:

1. It is well adapted for use in squadron signalling under conditions of rain, fog, darkness and motion of ship. The rain, fog and other conditions of weather do not affect the transmission through space, but dampness may reduce the range, rapidity and accuracy by impairing the insulation of the ærial wire and the instruments. Darkness has no effect. We have no data as to

the effects of rolling and pitching, but excessive vibration at high speed apparently produced no bad effect on the instruments, and we believe the working of the system will be very little affected by the motion of the ship.

2. The accuracy is good within the working ranges. Cipher and important signals may be repeated back to the sending station if necessary to insure absolute accuracy.

3. When ships are so close together (less than 400 yards) adjustments (easily made) of the instruments are necessary.

4. The greatest distance that messages were exchanged with the station at Navesink was 16.5 miles. This distance was exceeded considerably during the yacht races when a more efficient set of instruments was installed there.

5. The best location of instruments would be below, well protected, in easy communication with the commanding officer.

6. The spark of the sending coil or of a considerable leak due to faulty insulation of the sending wire would be sufficient to ignite an inflammable mixture of gas or other easily lighted matter, but with the direct lead (through air space if possible) and the high insulation necessary for good work, no danger of fire need be apprehended.

7. When two transmitters are sending at the same time, all the receiving wires within range receive the impulses from transmitters, and the tapes, although unreadable, show unmistakably that such double sending is taking place.

8. In every case, under a great number of varied conditions, the attempted interference was complete. Mr. Marconi, although he stated to the board before these attempts were made that he could prevent interference, never explained how nor made any attempt to demonstrate that it could be done.

9. Range of signalling: Between large ships (heights of masts 130 and 140 feet above the quarter deck) the range is at least 35 sea miles at sea and 16.5 miles or less when tall buildings of steel frames interfere. Between a large ship (height of mast 140 feet) and a torpedo boat (height of mast 45 feet) across open water, signals can be read up to 7 miles on the torpedo boat and 8.5

miles on the ship. Communication might be interrupted altogether when tall buildings of iron framing intervene.

10. The rapidity is not greater than 12 words per minute for skilled operators.

11. The shock from the sending coil of wire may be quite severe, and even dangerous to a person with a weak heart. No fatal accidents have been recorded.

12. The liability to accident from lightning has not been ascertained.

13. The sending apparatus and wire would injuriously affect the compass if placed near it. The exact distance is not known and should be determined by experiment.

14. The system is adapted for use on all vessels of the Navy, including torpedo boats and small vessels as patrol scouts and despatch boats, but it is impracticable in a small boat.

15. For landing parties the only feasible method of use would be to erect a pole on shore and then communicate with the ship.

16. The system could be adapted to the telegraphic determination of differences of longitude in surveying.

The board respectfully recommends that the system be given a trial in the Navy. Respectfully,

J. T. NEWTON, Lieutenant Commander, U. S. Navy.
J. B. BLISH, Lieutenant, U. S. Navy.
F. K. HILL, Lieutenant, U. S. Navy.

To the Chief of the Bureau of Equipment.

NEW GERMAN DRY DOCK

The new Kaiser Dry Dock in the Kaiserhafen at Bremerhaven is the first German dry dock entirely built of stone, the largest in Germany, and one of the largest in the world. It has an effective length of over 722 feet, a middle breadth of 90½ feet, and an effective depth of 31 feet. The sill of the dry dock is 7 meters below Bremerhaven zero, and 1,056 meters below the ordinary high water of Weser. The new dry dock, with its entrance basin is situated in the north corner of the Kaiserhafen, and there is a wet dock of 200 meters length, in which ships can be repaired

when floating, and further space for another dry dock of the same dimensions as that already constructed. A turn bridge, over which several lines of rails are conducted, connects the two sides of the entrance to the basin. The closing of the dry dock is done by a lifting pontoon, which can be removed from the outer end of the dry dock 60 meters inside the dry dock in order to save time and expense when vessels of smaller size are docked. A steam water engine is used for emptying the dock, which can be effected in from two to two and a-half hours, whereby 75,000 cubic meters of water are raised. On each side of the dry dock two cranes of 50 tons capacity are erected, and in the southeast corner of the wet dock a crane of 150 tons lifting capacity is constructed. All these cranes, as well as the lighting of the whole dock, is done by electricity. The North German Lloyd has taken the new dry dock in lease for twenty-five years, and under the condition that the Imperial German navy can also always use it.—"Engineers' Gazette."

TESTS OF BRITISH GAS ENGINES.

At the Edinburg show of the Highland and Agricultural Society of Scotland, which took place during July, a number of gas engines were exhibited and a committee appointed to test their relative efficiency. The power developed by each engine was obtained by the Prony brake and by the indicator, and the amount of oil fed to each engine was measured. The engines were required to run for four hours on the first day at full declared brake load. This was followed on the second day by a two-hours' run at half load, afterward by an hour's light-load trial; finally each engine was run for a short time at its maximum load. This last trial was made in order to ascertain the maximum power that could be developed on an emergency. The Crossley, Stephenson, Pollock and Cundall engines were supplied with "Royal Daylight" oil of 0.796 specific gravity, and the other engines with "Russolene" oil of a 0.825 specific gravity. The results of the test are shown in the accompanying table, which is taken from "The Engineer":

SUMMARY OF TRIALS OF OIL ENGINES.

.....	Crossley Bros., Limited.	Campbell Gas Engine Co.	R. Stephenson & Co.	Blackstone & Co.	Tangyes, Limited.	R. Cundall & Son.
Diameter of cylinder, ins..	10	12½	7	9½	11	8¾
Stroke, inches.....	18	21	12	18	16	15
Full-power trial:						
Revs. per min., mean...	204	188	252	190.3	200.1	227.7
Mean effective pressure, lbs. per sq. in..	64.52	49.5	5.39	56	62.2	...
Explosions per minute, mean.....	87.25	76	118.5	81.4	89.75	...
Indicated horsepower..	20.09	24.48	5.39	14.68	21.43	...
Mechanical efficiency..	.771	.773	.582	.858	.842	...
Brake horsepower.....	15.5	18.93	3.14	12.6	18.06	8.77
Oil pr. B.H.P. pr. hour, pounds.....	.793	1.20	1.63	.746	.806	.962
Half-power trial:						
Brake horsepower.....	7.71	10.59	1.31	6.59	9.95	4.35
Oil pr. B.H.P. pr. hour, pounds.....	1.037	1.466	2.88	1.024	.930	1.57
Light trial:						
Total oil per hour, lbs..	4.03	8.23	4.43	3.4	3.375	4.24
Maximum-power trial:						
Brake horsepower.....	18.01	25.55	3.14	19.7	29.66	10.54

SHIPBUILDING IN DENMARK.

The Elsinore Ship and Machine Building Company has, during the last financial year, had a turnover of 3,271,000 kroner (£180,000), against 2,831,000 kroner the previous year. In wages it paid 1,030,000 kroner (£57,000), and 976 hands were employed. Including apprentices, the average wages have been 1,055 kroner (£58 12s. 3d.). By negotiations with the trade union an increase of the wages has been decided upon. The profits on the year amounted to 682,674 kroner (£38,000), 100,461 kroner have been written off, and 90,000 kroner added to the reserve fund. The shareholders receive a dividend of 6 per cent. There have been 121 ships on the company's slips, and 173 have been repaired; seven new steamers, with an aggregate of 7,710 tons, have been delivered. An extraordinary meeting of the shareholders of

the Danish Machine Manufacturing and Shipbuilding Company, which was formed earlier in the year, and acquired valuable sites and water power at the Strandmöller, has decided to purchase the concern known as the Stellerup Shipyard. A debenture loan of 300,000 kroner in this latter concern will remain unaltered, and each share of 2,000 kroner in the Stellerup Shipyard is exchanged for a 1,000 kroner share in the new company, and 15 per cent. is paid in cash. The share capital of the Danish Machine Manufacturing and Shipbuilding Company (Dansk Maskinfabrik og Skibsbyggeri) will be increased by 300,000 kroner. The Burmeister Shipbuilding and Engineering Company is at present very busy; a large order has now been finally secured from the Russian company, and great activity prevails both in the shipyard and in the engineering departments, which are being materially extended and where a number of large and entirely up-to-date machine tools have been installed. Electric motors have been adopted on a large scale.

CENTER OF GRAVITY OF LOCOMOTIVES—SIMPLE METHOD OF DETERMINING.

The determination of the center of gravity of locomotives is a laborious task when computed mathematically, because in order to be accurate the weight and location of the center of gravity of each and every piece should be ascertained and their moments above the rail figured out, but the labor being so great, assumptions are made which affect more or less the final figures. It occurred to the writer that a practical method could be applied and the following was therefore evolved:

Suppose that we have a body of symmetrical cross section, the weight of which is known. If this body be tipped slightly so that one of the edges upon which it stands is lower than the other, the center of gravity will be displaced laterally. If this body rests upon supports at the two lower edges only, then the lower support will sustain more weight than the higher one, due to the lateral displacement of the center of gravity, and if the angle is such that the center of gravity be vertically over the lower edge, the total weight will come on this edge, and the

body will be in unstable equilibrium. Thus, in Fig. 1, the whole weight will come upon the support B, but in Fig. 2 a portion will rest upon A and another portion upon B, but the sum of these two will be equal to the total weight. Let the weight of a symmetrical body be represented by W, the load on each sup-

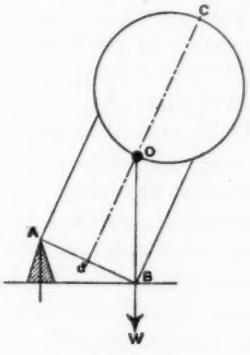


Fig. 1.

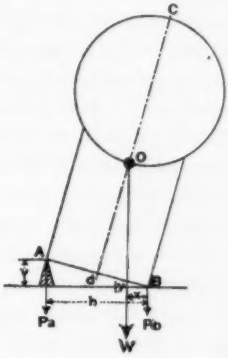


Fig. 2.

port by Pa and Pb, respectively; then Pa plus Pb equals W. Let also the horizontal distance between the supports be represented by h and the vertical difference by v; also the distance measured horizontally between the support, B, and a vertical dropped through the center of gravity be represented by x. Now, by equal moments $Pa \times h$ equals WX, and X equals

$$\frac{Pa\ h}{W}.$$

As the body is symmetrical, the center of gravity must be in the central axis c-d and at the intersection with the vertical through y, at a distance X from B, or at O. This may be laid off graphically or it may be calculated by similar triangles.

The reproduced photograph, Fig. 3, illustrates the application of this principle to locomotives. The engine was first carefully weighed on the track scales, with a certain height of water, etc., and was backed off the scales. The rail was then removed from the narrow side of the scale platform, and blocks laid close to-

gether, like ties, from the outer frame to the fixed or dead rail support, care being taken to see that the portion of the scale under these blocks was entirely free. A rail was laid to gage on these blocks, and a slope prepared at one end. All was now ready, and the beam being balanced, the water was brought to the same level as before in the boiler, and the engine run upon the new track, and the load upon the lower rail weighed. While the engine is upon the scales, a level should be run from rail to rail to determine the exact difference of level for use in making the calculations; in the case illustrated this was about 7½ inches. Of course, there is a slight error, due to shifting of the water sidewise in the boiler, which tends to exaggerate the result. The frames should be blocked over the boxes, so that the boiler will stand relatively to the wheels the same as on level track.

If care be taken, accurate results may be obtained, as, with the small elevation mentioned, an increase in weight of 25,000 pounds on the lower side of the engine was shown by the scales, the total weight of the locomotive being about 140,000 pounds.—G. W. Henderson, in the "American Engineer and Railroad Journal."

REPAIRING VESSELS AT CAVITÉ.

Naval constructor Hobson has some pertinent comment to make on the question of dry-docking facilities required by the Government at Cavité, which he embodies in a report submitted to the Navy Department recently, on the question of the wrecked vessels raised in Manila Bay, which are now being repaired at Hong-Kong under his direction. Mr. Hobson contends that economy demands that the United States establish its own dock and repair station, and shows that large sums would be saved which are now paid private firms at Hong-Kong for overhauling American warships.

His report is an argument in favor of the maintenance in the Philippines of an important navy yard and dry dock, where the largest and most powerful vessels of war may be overhauled and attended to. The report states that in compliance with the bureau's direction the three vessels under reconstruction, the *Isla de Cuba*,

Isla de Luzon and *Don Juan de Austrias*, are about 80 per cent. completed. The value of the vessels when completed, exclusive of armament, will be about as follows: *Isla de Cuba*, $215,000; *Isla de Luzon*, $215,000; *Don Juan de Austrias*, $180,000. Total $610,000. Raising and refitting have cost about $304,000, making a net gain to the Government on the three vessels of $306,000. The credit for this result is given to Naval Constructor Capps, who made the contracts. Thus the large engine parts were scarcely injured at all. This feature has an important bearing upon the wrecks still in Manila Bay, which he is to examine with divers when the vessels now in hand are completed. The longer period that they have been immersed may not have seriously injured the principal parts, and there may be similar advantage to the Government in further salvage, particularly as to the *Don Antonio de Ulloa* and the *Velasco*, sister ships to the *Don Juan de Austrias*, which, from all accounts, suffered less damage than those that have been raised.

Mr. Hobson adds: "There would be great advantage to the Government in the establishment in the Philippines of a yard thoroughly equipped with docks and plant capable of doing all the work of docking and repairing of the navy. The British Government is undertaking such an establishment here, though at great cost, involving the making and reclaiming of a large part of the land required. This would necessitate the employment of Chinese labor. This labor is not only unlimited, but it is equal to practically all the requirements of modern industry. Chinese do all the work inside and out for all the departments of the shipyard, white supervision being required only to show what is wanted. The Chinese have a remarkable natural aptitude. Their industrial capacity is simply marvelous. To the extent of my observations and inquiries, there is no place in modern industry which they can not fill."—"Scientific American."

THE COST OF CHEAP MEN.

Capitalists have been acquiring a little education of late in the matter of the considerations to be taken into account in

dealing with workmen. Some of them have believed that nothing needed to be regarded except wages. If you could save 25 cents a day on the pay of each man you hired, you would be just that much ahead. But there have been some incidents recently that have tended to upset this apparently reasonable theory.

For instance, after the Brooklyn Rapid Transit Company had got rid of most of its experienced men and put strangers in their places, it began to suffer from accidents, delays and complaints of patrons. It also found its receipts diminishing, and one of its officials alleged that some of the new conductors were "knocking down" 90 per cent. of the fares.

The other day the *Campania* came into port at New York with Lord Charles Beresford and a lot of other disappointed passengers, just too late to see the Dewey celebration. She had been delayed by a set of green firemen, taken on because the old hands were on strike. The extra coal alone consumed on the voyage would probably have more than covered all the demands of the strikers.

Last week the British merchant marine was disgraced by a repetition of the *Bourgogne* horror under the British flag. The steamer *Scotsman* was wrecked in the Straits of Belle Isle and a number of women perished through the ruffianism of the cowardly crew. When some of the men were arrested at Montreal they were found to be loaded with dresses, silk stockings, underwear, watches, jewelry, cameras, diamond rings, pins, rings, brooches, purses and sealskins, which they had stolen from the dying passengers. These men, we are told, were "green hands, who had been shipped on account of the strike in England of sailors and firemen."

Cheap men in these cases seem to have come rather high.—"Philadelphia North American."

RELATIVE CORROSION OF VARIOUS METALS.

The following results were obtained for the National Tube Co. and the Oxford Copper Co. by Henry M. Howe, October 17,

1899, in the loss of weight of wrought iron, soft steel and nickel-steel in pounds per square foot of surface per annum, when exposed to—

	Sea-water average.	Fresh-water average.	General average.
Wrought iron,	.1409	.1275	.10386
Soft steel,	.1612	.1204	.10906
Low nickel-steel,	.1173	.1021	.08299
High nickel-steel,	.04518	.04404	.03416
General average,	.11615	.09851	.08252

STABILITY OF THE *NEW ORLEANS* AND THE *ALBANY*.

In our issue of July 1, we commented at some length upon the sensational rumors regarding the instability of the *New Orleans*, which, emanating from the Washington press, were taken up and elaborated by the press of Philadelphia and other shipbuilding centers. As we pointed out at the time, inquiry at the Brooklyn navy yard, where the inclining experiments on the *New Orleans* were made, showed that these statements were based upon a misconception or a misunderstanding of the report of the inclining tests.

In the determination of her stability in light condition, the vessel was considered stripped of all consumable weights and was placed in the most unfavorable condition possible. She was entirely emptied of coal, water and stores, the coal representing a lightening of 800 tons and the water of 220 tons. Not only were the boilers and tanks emptied of water, but all water was removed from the double bottom. The ammunition, representing 120 tons, was also removed, and neither the crew nor their supplies were on board. Indeed, the ship was put into a condition which, if she were upon the high seas, would constitute her a derelict.

When this process of stripping was completed, a certain number of cast-iron blocks of known weight were shifted across the deck, and from the angles of inclination of the ship so obtained the metacentric height, or stability, was calculated. The results

showed that when the *New Orleans* is absolutely empty, she has a negative metacentric height of 0.48 foot, or about 5¾ inches; which means in lay phraseology that she would not, in this condition, float upon an even keel, but would take a slight list until, by immersing a fuller waterline, she found sufficient bearings. Now there is in this nothing unusual. It occurs whenever an ocean liner is absolutely empty, and provision is made in all merchant steamers, as in the *New Orleans*, for correcting the list by introducing water ballast into the double bottom of the vessel. The inclining experiments showed that when the *New Orleans* is fully equipped for sea, with all coal, ammunition, and stores on board, she has a positive metacentric height of 1.7 feet. Advantage was taken of the recent visit of the *New Orleans* to dry dock, preparatory to her voyage to the Philippines, to subject her again to a series of inclining tests, which showed practically the same results as those of last June.

In the report which was made to the Bureau of Construction and Repair, at Washington, it was suggested that whenever the ship at sea was approaching the light condition, because of depletion of her bunkers, ammunition or stores, it would be advisable to introduce a certain amount of water into her bottom tanks. There is nothing new in this suggestion; it has been made before with regard to other ships of our navy, and as a matter of fact the *Philadelphia*, which has considerably less metacentric height than the *New Orleans*, has to keep water in her double bottom to give her the desired stability.

Unfortunately, in transmitting the report of these tests of the *New Orleans* to the Secretary of the Navy, the bureau at Washington made the following comment: "This at once marks her as a *dangerous vessel*, requiring great care, when in service, on the part of the commanding officer." It is a matter of great regret, both upon the part of the officers who have commanded this fine vessel at sea and the officers of the construction corps, that such an unfortunate misconstruction should have been put upon the results of the inclining experiments. These gentlemen do not consider the *New Orleans* to be "dangerous;" ridicule the suggestion that she is untrustworthy; and they regret that

any such impression should have been gathered from what was an ordinary routine inclining test, such as is carried out upon every new vessel of the United States Navy.

In this connection it may be mentioned that tests of the *Albany*, sister ship to the *New Orleans*, which have been made at the Armstrong works, where the *Albany* is completing, show that in the empty condition she has a positive metacentric height of 1.22 feet, and a metacentric height, when fully loaded, of 2.69 feet. The difference in the results as found in the two vessels may be accounted for by the fact that the *Albany* was short of her full weight by an estimated amount of 321 tons, and that other estimated weights had to be taken out; a slight error in these calculated weights, or the presence of bilge water in either ship, might affect the results sufficiently to account for the difference.

In any case, it is reassuring to know that in respect of her seaworthiness the *New Orleans* is indorsed both by naval constructors and by the line officers who have sailed her in every kind of weather. The captain of a ship is always particularly alive to anything in the motions of his vessel in a seaway that betokens a lack of stability. He has a quickness of perception, born of long experience, which would detect this unpardonable fault at the first indication of its existence; yet we are assured by those who have had charge of her that even in the light condition she has shown ample evidence of stability.—"Scientific American."

ANNUAL MEETING OF THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS.

The "Engineering News" of November 23, gives a very excellent "brief" of the proceedings, which we reprint practically in full.

* * *

The seventh general meeting of the society was held at the house of the American Society of Mechanical Engineers in New York city on November 16 and 17. In most respects the meeting was a very successful one. There were fourteen papers on

the programme, and the majority of them received discussion. Considerable time was wasted, particularly at the first day's session, by the authors of the papers reading them in full. This practice is, however, a common mistake of convention work, and the naval architects are no worse in this feature than many of their sister engineering societies. Where the papers are printed and distributed well in advance of the meeting, reading them by abstract, or, in some instances, by title only, will usually promote rather than restrict discussion, and will save a great strain upon the patience and good temper of the majority of the members who have already studied the paper. This fact was evidenced in the work of the second day's session, when most of the papers were read in abstract, and when the discussion, instead of being curtailed thereby, was, if anything, more active than during the first day's meeting.

The opening sessions of the meeting were presided over by Rear Admiral Francis M. Bunce, U. S. Navy (retired), the president of the society, Mr. Clement A. Griscom, being absent on a trip abroad. Mr. Griscom's presidential address was read by the secretary, and was in part as follows:

Whatever may be the political, moral or constitutional aspects of a policy of expansion, it is not without advantages to shipbuilders. The large number of vessels purchased by the Government last year for use of the Army and Navy, together with increasing use of steam vessels in the coasting trade, have produced the greatest activity ever seen in our coast shipyards, both on the Atlantic and the Pacific oceans. The orders for large steel steam vessels now taken exceed largely those of any year in our history. The record on the Great Lakes is such as to tax the capacity of the shipyards of that district until the fall of 1900. There are now building or to be built on the lakes, 26 steel vessels of large size of an aggregate value of about $8,000,000, and an aggregate carrying capacity of 154,000 gross tons. These vessels comprise one passenger vessel, two steel barges of 7,000 tons capacity each, five steamers of 3,000 tons capacity, suited to trade between the Great Lakes and the Atlantic seaboard, and eighteen steam freight vessels of about 6,000 tons capacity.

On the sea coasts we have the unusual condition of nine steamships building for ocean commerce. At least nine large steam-

ers, recently built, have been added to the coasting or West Indian trade in the past year.

This is probably the first occasion that I have found any statistics in regard to American shipping industries of a character desirable to contemplate, and even now I feel obliged to accompany them with a note of warning, "One swallow maketh not a summer." The proportion of our export and import trade now carried in American bottoms is too small to be mentioned, and last year was smaller than ever before. To make this percentage a respectable one would require ten times the number of American shipyards working at full time for a number of years. While we have the materials, the tools and mechanics, the successful building of a modern vessel from a commercial point is in reality a triumph of organization of the multitude of diversified trades which it includes. This stage is yet to be reached, and can only be attained by regular systematic production. Production depends upon a market and upon traders who see a profit to be made in shipowning under the laws of the United States.

The secretary's report showed the total membership to be 573, not including the members elected during the meeting. The total receipts during the year from all sources were $5,614, and the total expenditures were $5,669. The balance in the treasury was $3,586, and the total resources of the society were $13,935, with no liabilities.

The first paper on the programme was presented by Mr. Spencer Miller, M. Am. Soc. C. E., and was illustrated by lantern slides and models.

Coaling Vessels at Sea.

The paper described briefly the various devices proposed in the past for coaling vessels at sea, and concluded with illustrations and a description of the cableway system devised by the author and soon to be tested with the U. S. S. *Massachusetts* and the collier *Marcellus*. This system was described in its general features as follows:

(1) It is proposed, with this device, for the warship to take the collier in tow, or the collier to tow the warship, leaving the distance between ships about 300 feet. This method of securing boats at sea is recognized as being safe.

(2) The warship to receive the coal will erect a pair of sheer

poles on its deck, which, secured by guys, will support a sheave wheel and a chute to receive the load.

(3) The collier is provided with a specially-contrived engine located aft the foremast, having two winding drums. A steel cable, $\frac{3}{4}$-inch diameter, leads from one drum to the top of the foremast, over a sheave, thence to the sheave on the warship, back to another sheave on the top of the foremast, thence to the other drum. This engine gives a reciprocating motion to the conveying rope, paying out one part under tension; a carriage secured to one of the parts passes to and from the warship, its load clearing the water intervening.

(4) A carriage of special form is provided with wheels which roll on the lower part to the conveying cable, and grip slightly but sufficiently the upper part of the cable. This carriage will carry bags of coal weighing 700 to 1,000 pounds. The load is held by a hook pivoted at the bottom of the carriage, which hook is held by a latch. When the carriage comes in contact with the rubber buffer on the sheave block at the warship, this latch is pressed in, thereby releasing the hook and its load. Should the carriage strike heavily at either terminus, the upper part of the cable will slip through the grip and no damage will be done.

(5) As soon as the bags are dropped, the direction of the rope is reversed, and the carriage returned to the collier. During the transit of the load an elevator car descends to the deck, bags of coal are placed thereon, suspended from a bale, and elevated again to the stops on the guides, so that when the carriage has returned to the collier, the pointed hook finds its way under the bale or hanger supporting the coal bags. The instant the load is hooked on, the direction of the ropes is again reversed, the carriage takes its load from the elevator and transfers it across the intervening space to the warship, and drops it again into the chute.

There was no discussion on this paper, and the next paper, on "Reasons for the Adoption of the Water-tube Boiler in the U. S. Navy," by Rear Admiral George W. Melville, Engineer-in-Chief, U. S. N., was read. The discussion brought out very little information in addition to what was given in the paper. The next paper was by Mr. John Hyslop, and had been written in response to the invitation issued by the society at its meetings of November 10 and 11, 1898, asking for papers on the subject of "Life Saving at Sea." In discussing this paper, Captain

George Randle, of the Atlantic liner *St. Louis*, suggested the adoption of very large ship's boats, capable of holding say 100 persons, carrying them athwartships on ways and launching them endwise on chutes exactly similar to the way in which ships are launched from the building ways. Captain Randle stated that experiments which he had seen conducted had convinced him that the plan was perfectly feasible.

The next paper was by Naval Constructor J. J. Woodward, U. S. N., and described in considerable detail the electrical installation on the new United States battleships *Kearsarge* and *Kentucky*. These are the first vessels of our navy on which the use of electricity as a motive power for the ship's auxiliary machinery has been adopted extensively. The only auxiliaries operated by steam on these two vessels will be those connected with the main propelling engines such as air, feed and circulating pumps, forced-draft blowers, ash hoists, etc., and the windlasses and steering engines. The discussion on the paper was very short, and turned chiefly upon the relative advantages of the two-wire and three-wire system of distribution for such conditions as prevail on board warships.

The next paper was read by Mr. Geo. W. Dickie, of the Union Iron Works, San Francisco, Cal.

A SIMPLER ARRANGEMENT FOR THE MECHANICAL APPARATUS ON WARSHIPS.

The present complicated condition of affairs in the arrangement of the various mechanical contrivances used on modern warships is due to two causes, as follows:

(1) Uncontrolled growth of new devices for doing the many things for which mechanism is required on these vessels, without the new devices being considered reliable enough to supersede the old. Hence, duplication and, in many cases, triplication of apparatus for doing one thing, for which one good device alone should be used.

(2) The system of divided control over the work, rendering it impossible to have a homogeneous design to begin with, that would enable the ship and all that is required of her to be treated as one machine, and provision made at the start for every function being considered with relation to every other function.

As a remedy, an arrangement is suggested, consisting in the construction of a tunnel or passage lengthwise of the vessel at the center and just below the protective deck, and the installation of all pipes and wires in this passage. From this central passage the pipes and wires branch off on each side to the various mechanisms located throughout the ship. All steam pipes are confined to the main-engine room, the auxiliary-engine room and electric-generator room, and all machinery outside of these rooms is operated by electric motors. The drainage pumps are electrically operated, and are located in six groups of three pumps each at regular intervals lengthwise of the central passage. The suction mains for these pumps, two in number, are located on each side of the center-line bulkhead just above the bottom stiffener brackets and the various suctions branch off transversely. The laterals and standpipes from the fire mains are arranged in a similar manner to the suctions from the drainage mains. Doors at frequent intervals in the central passage give access for repairs, inspection, etc. In conclusion, the duplication of devices for doing the same work is condemned, and it is urged that the duplication be abandoned. The use of mechanical arrangements for closing bulkhead doors singly or in groups from a central station at a distant part of the vessel is condemned as a useless and objectionable complication of apparatus.

THE WOODEN SHEATHING OF THE U. S. S. *CHESAPEAKE*.

The *Chesapeake* is a practice ship being built at the Bath Iron Works, Bath, Me., for the U. S. Naval Academy, and launched June 20, 1899. One notable feature of the vessel is that the steel hull is entirely sheathed with wood. The woodwork comprised a keel of teak, and a false keel of oak spiked to the main keel, which in turn was fastened to the metal keel plate with $1\frac{3}{8}$-inch brass screw bolts. The sheathing proper is of 4-inch Georgia pine, except for the two top strakes, and near the stem and stern, where $3\frac{1}{2}$-inch planks are used. The upper edge of the sheathing, which reaches 26 inches above the water line amidships, with an up-sheer forward and aft of 15 inches and 12 inches, respectively, is covered with a 3-inch by 3-inch angle. The planking is

fastened to the steel hull with ¾-inch naval-brass screw bolts. Before applying the sheathing the metal hull was carefully cleaned and a thick coat of red and white lead was applied, and after the sheathing was applied a special putty was injected through holes bored in the planks into the space between the planking and the steel hull. The mixture injected consisted of 63.57 per cent. white lead, 32.1 per cent. dry red lead, and 4.32 per cent. linseed oil. Altogether 6,857 pounds of this mixture was pumped between plating and planking. The injected putty was confined to a series of longitudinal sections in the following manner: Each third strake of planking, commencing with the top of the garboard strake, was lightly chinked with a thread of oakum before the next strake was put in place. The brass screw bolts were composed of 62 parts best selected copper, 37 parts Silesian zinc and 1 part tin. The specifications required these bolts to be bent cold to an angle of 40 degrees without cracking or fracture, and to have a tensile strength of 42,500 pounds per square inch. The mean of 21 test pieces gave an average tensile strength of 47,204 pounds per square inch. The heads of the bolts were countersunk and packed with hemp grommet and red lead putty, and were fastened by a nut and washer inside the iron hull plating. The counter sink of the bolt heads was filled with Portland cement. The total weight of the sheathing and its attachments was 174,196 pounds, of which the metal used comprised 11,883 pounds. The approximate area of sheathed surface was 7,583 square feet.

SECOND DAY'S SESSION.

After some routine business the reading and discussion of papers were resumed. The first paper was read by Mr. W. I. Babcock, manager Chicago Shipbuilding Co., and described the duplicate mold system of building vessels employed at the yards of that company, and to a greater or less extent in other shipbuilding yards on the Great Lakes. The contents of the paper being of special rather than of general interest, and it being difficult to abstract it satisfactorily, we shall refer such of our readers as wish to study it carefully to the published proceedings of the society where the details and illustrations can be examined. In

discussing this paper, Mr. George W. Dickie, of the Union Iron Works, called attention to the great simplicity of design and construction which had been developed in the building of ships for the bulk freight service of the Great Lakes. Some of these features he thought could be studied to advantage by marine architects with a view to their adoption in or adaptation to the design and construction of seagoing ships. A number of other members who had had experience with the duplicate mold system described in the paper confirmed the opinion of the author regarding its convenience and economy.

The next paper was presented by Mr. James Dickie, Union Iron Works, San Francisco, and described the system of overhead cranes and side stagings used at the works of that company.

Shipyard Building Slips with Overhead Crane and Staging Arrangements.

The need of some means by which material can be hoisted and deposited in any position on a vessel while it is under construction has developed a number of overhead devices which are now in general use in shipyards. These devices are of comparative recent development. Previous to 1884 the only means used to hoist material on a vessel while building was the derrick pole with the swinging gaff. Among the forms of cranes now in use are the following: (1) The cantilever crane, of which the one employed by the Newport News Shipbuilding Co. is a good example; (2) the overhead crane or gantry, so much used on the Great Lakes, which travels all over the vessel, with rails on the ground on each side; (3) the large gantry employed in building the *Oceanic* at the works of Harlan & Wolf, at Belfast, and (4) the overhead framework construction such as is used at the works of Swan & Hunter, in England, and the Union Iron Works, at San Francisco. At the Union Iron Works there are four of these frameworks in use. The framework consists of a series of bents which are placed about 12 feet apart and form a skeleton steel-like structure over the vessel. The bents are firmly braced together longitudinally, and the entire framework is 408 feet long and 78 feet wide. A 50-foot crane at each end

enables the framework to cover a vessel 500 feet long, and for longer vessels the framework can easily be lengthened by adding bents at the ends. The whole length of the framework is traveled over by two bridge cranes, and the jib cranes are spaced at such intervals along the sides that their fields of operation overlap each other. The paper continues the description as follows:

The apex of the roof is 3 feet from the center, making one crane 6 feet longer than the other. This is done to enable pieces, such as beams, etc., to be landed on the center line. The cranes are electric and travel at the rate of 180 feet per minute fore and aft, and 90 feet crosswise, and the hoisting speed is 90 feet per minute, with a lifting capacity of 5 tons. A manila rope is used for hoisting, which gives considerable elasticity, and enables a plate to be bolted up if within an inch or two of the place. For plating under the bottom and under the counter we use a wire rope, rove through the plate and the corresponding hole in the frame and toggled under the plate, which enables the plate to be drawn close up to its place.

One feature of the structure is the facility with which staging can be erected. Where the ship is large, the spauls, which are 4 by 8 inches, are rove through the main posts and held by loose bolts at the ends. Where the vessel is narrower, a standard made of 3 by 6 inches double is set on top of the ground, and held from canting by the rigidity of the spaul in the posts, thus saving all bracing. As the posts are all 12-foot centers, we use 2 by 12 inches by 26-foot plank for staging, which we find strong enough for any work, and light enough to be easily handled.

We propose, in our new slips, to fit up cranes for riveting. These cranes are made of 8-inch T-bulb beam, and are supported by two suspension rods. The trolley for the riveter runs on the lower flange of the beam; the wheels being 20 inches in diameter makes it very easily moved.

The machines we are at present using are the toggle-jointed air machines, which drive $\frac{7}{8}$-inch rivets with a 30 inch gap. The weight of the machine is about 1,400 pounds. It moves so easily that the operator has no difficulty in making the nicest adjustment. We are also using the percussion air machine, with a 4 or 6-foot gap, which weighs only about 250 pounds. As will be noticed, the cranes for riveting are only 32 feet long, with a beam hung from them. This enables us to do hoisting and riveting at the same time, as all the material is hoisted up over the vessel

and carried along near the center line to a point opposite to where it is to be landed. This center cross-beam can be raised or lowered to suit the work on the vessel. When working on the inner bottom it will be down; when on deck it will be close up to the cranes.

We have studied all the various overhead cranes and claim for this structure that it is no more expensive in first cost and fulfills more functions than any other, except the one at Messrs. Swan & Hunter, on the Tyne, and in comparison with it I think we have the advantage in staging. We find no disadvantage in having the posts as close as 12 feet, all the hoisting being done at the upper end, then carried over the vessel to the required place, and, when there, lowered into its proper place. As we use no side shores above the bilge, the top sides are always clear for lowering a shell plate into position, and, as I said before, the bottom plates and plates under the counter are hoisted from the ground with a wire rope rove through the corresponding hole in the frame, and toggled outside the plate; thus the entire plating can be put on the vessel with these cranes.

We have two cranes at the upper end of the structure. These we use for frame riveting and all other pieces that can be riveted before going on board.

As mentioned before, we use the structure to keep the upper works of the vessel fair while in the early stages. For fairing the upper works we use turnbuckles from the sides of the vessel to the structure, and pull in or slack out when necessary. All of which is done by the men on the upper stage, at small cost and with much convenience.

In discussing this paper, Mr. John Platt pointed out that there was some misconception of the purpose of the Harlan & Wolf gantry crane employed in building the *Oceanic*. This crane was in the first place intended only for use in building very large vessels, and, second, it was designed purely for carrying riveters, and not for handling materials. The material was all handled on the ground alongside the vessel by cars, and was hoisted on board by derricks. The gantry was used for riveting only, and that it seems to have proven successful for this purpose was evidenced by the fact that Harlan & Wolf are building two more exactly similar, except for some slight changes in dimensions.

The next paper, describing the "Designs for the *Denver* Class Sheathed Protected Cruisers," for which bids have recently been

received, was by Rear Admiral Philip Hichborn, Chief Constructor, U. S. N. In a written discussion Chief Engineer George W. Melville deprecated the fact that the writer of the paper should have felt called upon to defend the design of the new cruisers against newspaper criticisms. He also thought the implied criticisms of the cruisers of the *Raleigh* and *Cincinnati* class were somewhat unfair, and said:

The *Cincinnati* and the *Raleigh* were designed at a time when there was a perfect craze for big speed in all classes of vessels. The statement had been dinned in our ears so much so that we must get at least as good results from every ship as were obtained from foreign ships, and must, if possible, do better, that our designers were working, as one might say, under the lash. Just before the designs were prepared the British Admiralty had got out designs for what were known as the "M class of cruisers," which were exactly the characteristics of the *Cincinnati* and the *Raleigh* in the way of putting a large power in a small hull and aiming at a very high speed. The history of those ships has been very much the same as the history of ours, in that they have not been a brilliant success.

Respecting the speed of the *Raleigh*, Admiral Melville pointed out that her speed of nine knots shown at Manila was obtained after she had been six months without cleaning, and that after she was cleaned at Hong-Kong she regularly made an average of twelve and thirteen knots for long distances on her run home from Manila.

Referring to the question of speed, Mr. George W. Dickie, Union Iron Works, commended the courage of the Navy Department in reducing the speed of the new cruisers to sixteen knots and giving the vessel greater coal endurance. He regretted, however that a soft wood like pine had been adopted for the sheathing. A hard wood like teak was far better and but a very little more expensive. Naval Constructor Francis T. Bowles expressed himself decidedly as being against sheathing for a steel vessel. It might be necessary as long as a considerable number of vessels were required in the far East, but only until a dry dock could be built there.

The next paper was read by Assistant Naval Constructor R. M. Watt:

NOVELTIES IN SHIP FITTINGS.

This paper described a number of new devices in fittings which have recently been employed in some of the vessels of the U. S. Navy. The novelties described include a water-tight metal skylight for use over messrooms and staterooms; a metallic folding berth for ships' staterooms; an asbestos sheathing for finishing staterooms and living quarters; and an electrically-operated watertight bulkhead door. The new bulkhead door is similar to the watertight sliding door devised by Mr. W. B. Cowles ("Eng. News," Aug. 18, 1898), fitted for operation by electric power instead of by hydraulic power.

The motor used is 1-H.P., compound-wound, of the short-shunt type, the short-shunt coils being relatively weak, and wound outside the series coils. The circuits are so arranged that for raising the door, only the series coils are in circuit, giving quick and easy starting, while for closing the door where it may be necessary to cut through coal, the shunt and series coils are both in circuit.

The electric current taken from the mains passes through a three-point spring-lever switch. Moving the lever to the right or left completes the circuit through the motor and raises or lowers the door. The shaft of the switch handle pierces the bulkhead so that the switch may be thrown from either side. A spring returns this lever to its central position, and when in this position, the door-closing circuit may be completed from one or more distant stations in any part of the ship. The door-opening circuit can be completed only at the door, and when completed cuts out the closing circuits.

Beyond the spring-lever switch, the circuit contains a limit switch opened by a bell-crank lever when the door reaches either of its extreme postions. The shaft of the pinion that engages in the door rack, carries at its end another pinion that gears into a spur wheel keyed to a shaft that carries the bell-crank levers for working the limit switches. The position of these levers may be adjusted for varying the lift of the door.

Beyond the limit switches, the circuit contains two Sprague solenoid gravity controllers which throw in either the series or the series and shunt fields of the motor. These controllers have

carbon and copper contacts, which prevent pitting of the copper bars, but necessitate occasional adjustment of the carbon tips. The controllers are fitted in a watertight receptacle with a hand hole and glass cover; this allows constant inspection of the carbons, and their adjustment when necessary, without removing the front of the receptacle. The working of the controllers is easy and simple, and there are no springs or pins; the copper bars are carried on phosphor-bronze flexible plates allowing for a little wear of the carbons without readjustment, and ensuring good contacts. All the parts are enclosed in watertight boxes.

Speaking of the progress made in the task of rendering ships' fittings free from danger from fire, the paper gives the following interesting summary of present practice:

Six years ago the divisional bulkheads were of untreated wood; likewise the ceiling overhead and the ceiling or sheathing against the side of the ship. The berths, lockers and all the furniture, including a closed-in wardrobe, also the ship's ladders, shelving everywhere, etc., were of untreated wood. Now, the constant endeavor is to reduce woodwork everywhere to a minimum, steel or some other non-combustible material being substituted wherever practicable, and where wood is used at all it is required to be subjected to an approved fireproofing process. The present practice at Brooklyn Navy Yard is as follows: The unnecessary overhead ceiling is altogether omitted. In crew's quarters the outboard sheathing is omitted, but in officers' quarters asbestos sheathing is fitted. All divisional bulkheads are built of light corrugated sheet metal (first fitted on the *Texas* in 1892) and finished with a sheet-metal cornice (first fitted on the *Atlanta*). The uncleanly wooden berth is replaced by a compact and cleanly metal folding berth. The wooden ladders are altogether done away with, and metal ladders with some form of non-slipping tread are in general use. For the unsatisfactory wooden skylights over messrooms and inboard staterooms a watertight metal skylight is substituted. At the present time the desks, chairs, tables and chiffoniers used on naval vessels are made of fireproofed wood; but samples of metal furniture, by which the use of wood for this purpose will be entirely dispensed with, are now being prepared at the Brooklyn Navy Yard for the purpose of selecting types for naval use. All lockers supplied to the *Atlanta*, including rifle lockers, petty officers' lockers and marines' lockers, are of metal, and the *Atlanta's* cabin has been fitted with a metal roller-top desk.

In the discussion which followed, a member called attention to the fact that in the new Russian war vessels now being built at the Cramps' yards, all the sheathing was asbestos, all the furniture except the chairs was of metal, and the deck planking was the only woodwork in the whole ship. Mr. W. B. Cowles spoke at some length regarding the comparative advantages of hydraulic or pneumatic power and electric power for operating bulkhead doors. He thought that either hydraulic or pneumatic power lent itself more directly to the work to be performed than did electric power, and was more cheaply transmitted. He also criticised some of the details of the door-tightening apparatus described in the paper. The next paper was by Lieutenant A. B. Niblack, U. S. N.

TACTICAL CONSIDERATIONS INVOLVED IN TORPEDO-BOAT DESIGN.

The highest development of the present type of torpedo is one about 16 feet long and 18 inches in diameter, and carrying a charge equivalent to 110 pounds of gun cotton. The highest pressure used in the air flasks to operate the engines is 1,500 pounds per square inch, giving a speed of 30 to 32 knots at 400 yards, 28 to 30 knots at 800 yards, and 26 knots at 1,000 yards. Some unusually long torpedoes for coast defense run as high as 30 knots for 1,000 yards and 24 knots for 2,000 yards. The torpedo is not a delicate instrument. Recent inventions and improvements have worked a complete revolution in the status of the torpedo. The first improvement is the application of the principle of the gyroscope to the steering rudders of the torpedo, and the second is the perfection of apparatus that will safely and accurately launch torpedoes from the under-water broadside of a rapidly-moving ship. The latter invention practically does away with above-water discharge in large ships, and the former has doubled the accuracy of fire.

Torpedo-boat attack, to be reasonably certain, must be a surprise. Attacks are made in groups of boats, and a single boat would attack only as a forlorn hope. A successful attack is, therefore, a question of team work.

In approaching to the attack, previous to discovery, reduced speed must be used so as to avoid white bow waves, smoke and flame, and that peculiar and far-sounding hum which accompanies fast-running machinery. Once discovered, or once within striking distance, high speed becomes important, but it takes some little time to attain it after having once slowed. As between a speed of 20 and one of 30 knots the time it takes to cover 1,000 yards is only as 90 seconds to 60 seconds. Can the 30-knot boat pass from 20 to 30 knots in 30 seconds? If you can build three boats of 22 knots for what two of 30 cost, and if the greater the number of attacking boats the better the chances, is it not wise to forego phenomenal speed? This craze for great speed is illogical, and tactically it is indefensible. Back of it is generally an advertisement for somebody. People who handle torpedo boats have never sanctioned it. What they do ask is that boats be built in groups on identical designs, and that every reasonable effort be made to standardize fittings. As long as fittings are standardized, we may improve groups progressively from year to year as experience dictates.

The vast majority of torpedo boats are single-screw boats. Single-screw boats with bow rudders handle quite as well as twin-screw boats without, and it is claimed for the single-screw boat that there is a saving in oil and the number of men required to operate the machinery; there are fewer moving parts and less liability of breakdown, and the weight and dimensions of the machinery are smaller.

As torpedo boats abroad are frankly intended to maneuver or cruise in groups, questions of spare parts, breakdowns, shortage in supplies, etc., are not so serious, since the boats rely on one another somewhat in cases of emergency. Probably no country has developed her torpedo-boat system so thoroughly as Germany. Fully 90 per cent. of her boats were built by Schichau, and the custom is to order them in groups of eight, all practically of similar design and with interchangeable parts. The tonnage has gradually increased from 85 to 140, as at present. Six of these boats form a group for maneuvering purposes, so that two of the eight are kept in reserve to take the place of any that may come to grief. There are ten large division, or "D" boats, of from 250 to 380 tons displacement, and from 1,800 to 5,500 H.P. They are each a sort of flagship, or "mother" boat,

for each group of six smaller ones, and accompany it everywhere. This division, or "D" boat, carries the heavier spare parts for the six accompanying boats, such as cylinder heads, piston rods, propellers, and a reserve supply of stores and fittings. Each "division" has its headquarters at a certain navy yard, and has a group of small storehouses at the water front, one for each boat, including the "D" boat and the two in reserve. When a whole division is in the second reserve all the stores of each boat are in its own storehouse, and the group of boats is tied up near the group of storehouses. Any deficiency in stores or fittings are made up from the large central torpedo storehouse, where all articles are standardized. In the winter the boats in reserve are kept at a uniform temperature by means of steam coils, connected with the shore by piping. Only when repairs are needed are boats hauled out, so that the division may always be ready to be put into commission for trials in twenty-four hours, and ready for war in forty-eight. If in drills or cruising a boat is injured, it is astonishing to see how quickly a spare boat of the group is forthcoming, and ready with the crew of the injured boat. Boats in the second reserve are looked out for by the navy-yard force, and a vessel under repair is always on the second reserve.

Oil fuel recommends itself for torpedo boats as compared with coal, for numerous reasons. Moderate reliable sea speed coupled with a large capacity for carrying and distilling fresh water is the fundamental requirement for a torpedo boat.

All this suggests the question, "What are the desirable characteristics of a first-class sea-going torpedo boat?" The answer here given is:

(1) It should be as small as is consistent with sea worthiness, so as to offer as small a target and be as little visible as possible, and, at the same time, should offer a reasonably stable platform for its torpedo tubes.

(2) It should be designed to have as small a bow wave as possible; its machinery should be as nearly noiseless as practicable; and it should not show flames or smoke from the stacks.

(3) It should have a large fresh-water tank capacity and be fitted with two smaller evaporators and distillers in preference to one larger one.

(4) It should have a reasonable bunker capacity. If for coal, the design should have in view the future use of liquid fuel.

(5) The efficiency of the boat depending so largely upon the physical condition of the crew, habitability should receive due consideration in the design.

(6) Speed is not essential, although desirable, but a moderate, reliable sea speed, obtained without forcing and without noise, flame and vibration should be striven for.

The discussion which followed this paper turned almost entirely on the question of speed, and the opinion was very generally expressed that in seeking for exceedingly high speed for torpedo boats many far more essential qualities had to be sacrificed, such as habitability, strength and endurance, coal capacity, etc. It was also pointed out that too many different kinds of service had been demanded of torpedo boats in actual employment. They had been required to do blockade duty and to act as despatch boats, and required to keep at sea in all sorts of weather. The result had been that they had suffered damage, and had to be repaired. The experience of the Spanish-American war and the Cretan blockade by the English during the Greco-Turkish war had shown conclusively that the modern torpedo boat would wear itself out in a very short time when called upon to do continuous duty at sea.

The papers on the "Progressive Speed Trials of the *Manning*," by Professor Cecil H. Peabody, and on "The Action of the Rudder," by Professor Wm. F. Durand, were presented briefly in abstract by their authors. Both papers were of a mathematical character and were only briefly discussed. The same statement is true of the paper on "Beam Formulas Applied to Vertically-Stiffened Bulkheads," by Mr. H. F. Morton. The convention closed with a banquet on the evening of the last day's meeting, at which there were a number of invited guests.

During the first session the following officers were elected for the ensuing year: President, Clement A. Griscom; First Vice President, W. T. Sampson; Vice Presidents, Francis M. Bunce, Charles H. Cramp, Frank L. Fernald, Philip Hichborn, Geo. W. Quintard, Irving M. Scott, Edwin A. Stevens; Secretary and Treasurer, Francis T. Bowles.

CAPACITY LIMITS IN DIRECT-CURRENT MACHINES.

In electrical machinery the maximum possible rate of work is far beyond the practical limit. A steam engine, at a given speed, cannot work at a greater rate than that which corresponds to boiler pressure through the entire stroke of its piston. If heat can be got rid of fast enough to prevent destruction of its materials an electric generator or motor does external work at its maximum rate when one-half of the electric energy generated in, or applied to, the armature coils is wasted there as heat. In this case the efficiency of the machine, disregarding the losses in magnet coils, local currents, hysteresis and friction, is 50 per cent. As the normal losses in armature windings of large and medium-sized machines is usually from 1 to 3 per cent. at full rated load, the enormous increase possible is evident. As a matter of practice, none save experimental or very small machines, are ever built in which the maximum rate of work above indicated could be realized. The two practical limits of capacity in direct-current dynamos are determined by the heating of the conductors and sparking at the brushes. The electric circuit, consisting of the windings, in an electric machine is separated from the other metallic parts by cloth, paper and other materials which may be injured by heat. This insulation is absolutely essential to the operation of the machine. It is found, as a matter of experience, that cloth and paper when kept in contact with metal at much above 250 degrees Fahrenheit, rapidly deteriorate in insulating properties and mechanical strength. This fact makes it imperative that the maximum rise in temperature of an electric machine, plus the temperature of the surrounding air, shall not exceed the limit of 250 degrees Fahrenheit.

Dynamos and motors are apt to be operated in basements and engine rooms where the temperature is as high as 120 degrees Fahrenheit, and it is common in good practice to limit the maximum rise above the surrounding air, in the windings of electric machines to 90 degres Fahrenheit. As the heat developed in armature windings varies as the square of the current, that is, as the square of the rate of work, the maximum temperature rise increases rapidly with the rate of work, in a given machine. The

rise in temperature that will take place in a particular machine under continuous operation at a certain load depends on the rate at which the parts of that machine dissipate heat. As is well known, a body in free air dissipates its heat the faster, the higher its temperature above that of the surrounding air. Complying with this law, the windings of electrical machines, when put in operation at first, give off but little heat, and the temperature increases up to the point where the energy expended in the windings just equals that dissipated as heat. In small machines the maximum rise of temperature may frequently be reached in three or four hours' run at full rated load, while in large sizes the time usually extends to ten hours or more.

An electric machine may, however, be brought to its maximum temperature for rated load by operation during a shorter period than would be necessary with that load at a properly determined greater load. It is at once evident from the above, that rise of temperature in the windings is but a slight limit to momentary overloads or even to those of some few minutes' duration, since a comparatively small amount of heat is generated in the coils during these short periods by the extra load. The heat limit to capacity in electrical machinery thus requires a considerable time for its operation, and is cumulative, tending to the destruction of the insulation.

The limit imposed by sparking at the brushes is immediate in its action and but slightly destructive, while, intimately connected with it are tendencies to reduce at once the output. To understand the phenomenon of sparking and its production by an overload, a glance at the function of a commutator is necessary. In a direct-current generator of ordinary construction the commutator is but a series of connections to the armature coils at stated intervals, for the purpose of brush connection. This fact is well illustrated by the practice of two well-known makers, who in some large machines arrange the brushes for direct contact on the bars forming the armature winding.

That part of the armature winding with which the brushes makes direct connection is subjected to a reversal of the current flowing in it at the time it passes the brush, since the current divides at

the brush contact, one-half flowing through the winding in each direction. The strength of the magnetic field through which the conductor is moved must have a certain relation to the current flowing through the conductor, if reversal is to be accomplished without sparking at the brushes. In all well-designed dynamos the distance between the face of the pole-piece and the iron of the armature coil is proportioned with special view to sparkless commutation, thus making its length much greater than is usually necessary for mechanical clearance. This air gap generally requires about 70 to 90 per cent. of the exciting power of the magnet windings, the remainder being utilized to force the magnetic flux through the iron circuit of the machine. As the magnet winding requires more copper than any other part, and constantly consumes energy while the machine is at work, it is desirable to keep the magnetizing force required for the air gap as small as consistent with good operation. To allow for temporary overloads, however, it is customary to so design apparatus that the sparking limit allows somewhat greater output than the heating limit. This last is particularly true in machines intended only for intermittent work, as crane motors, where an all-day load, quite within the sparking limit, would seriously injure the insulation of the windings.

An excessive current in the armature coils produces sparking, and this latter is usually obviated in some degree by changing the angular position of the brushes on the commutator to a point where the commutating coils will be in a stronger magnetic field. A reaction of the armature on the magnets results from the brush movement just noted in such a way as to decrease the total magnetic flux and, consequently, the electric pressure and output in the case of a dynamo.

Detection of overload through rise in temperature requires some time and careful observation, but when the sparking limit is exceeded the trouble is at once apparent.—Alton D. Adams, in "Engineering News."

MISCELLANEOUS.

PETROLEUM MOTORS.—The high economy which may be obtained by the complete combustion of liquid fuel in an internal-

combustion motor is now generally conceded, and as a result there have been numerous attempts to design motors which shall prove acceptable for general use. The Diesel motor has been fully noticed in these columns at various times, and now we have the Dopp motor, which was discussed at a recent meeting of the Verein deutscher Maschinen-Ingenieure, the account being published in "Glaser's Annalen."

Dopp maintains that the high compression advocated and used by Diesel is not necessary to the attainment of superior thermal economy, and claims that equally good results can be secured by the use of vaporized petroleum, drawn into the cylinder with the proper proportion of air, and burned under practically the same conditions as obtain when gas is used in a well-designed gas engine.

It seems to be generally admitted that the main element in the economy of a petroleum motor lies in the complete combustion of the fuel. While this is secured by providing a compressed atmosphere, it does not appear that it is necessary to use a compression materially greater than is now employed in the gas engine. The Dopp motor does not differ in general construction from an ordinary gas engine, except that the petroleum fuel is gasified by the heat of a lamp before it is drawn into the cylinder, and the excellent economy which appears in the regular service is claimed to be due only to the completeness of the combustion, attained by a thorough mixture of the fuel with the proper quantity of air.

Herr Dopp gives figures from a number of his motors in daily use which show a consumption of 0.197 to 0.240 kilogrammes of petroleum per horsepower hour, the lower result being obtained with a 10-horsepower motor after it had been in practical service for more than eleven months. This result is better than was attained by the Diesel motor of twenty horsepower tested by Professor Schroter, although under less favorable conditions.

Herr Dopp maintains, as has been claimed by others, that the Diesel motor by no means realizes in practice the theory enunciated by its designer, and shows that some of the fundamental

points which, according to the theory are essential to the highest economy, are distinctly controverted in the working of the motor. From this he deduces that the high economy of the Diesel motor shows that the theory is not sustained.

An important feature of the motors constructed by Herr Dopp lies in the fact that they can be constructed and operated in a satisfactory manner for small powers, good results being obtained with motors of two to five horsepower, while the construction of the Diesel motor is such that it does not appear advisable to make them for less than twenty horsepower.

Regardless of the theoretical questions at issue, there seems to be little doubt that very simple, efficient and convenient petroleum motors can be made upon the same general design as that already in public use for gas, and that care in design and in the correct proportion of air to fuel supply can, with a moderate degree of compression, insure such a complete combustion as to leave little or no trace of soot either in the cylinder or in the exhaust gases. Under such circumstances there can be little doubt that the petroleum motor has a most useful future before it, especially for small powers.—"Engineering Magazine."

PULVERIZED FUEL.—The attention which is now being directed toward the prevention of smoke in connection with the generation of power by the combustion of coal has awakened renewed interest in the possibilities of pulverized fuel. An exhaustive review of the past and present practice in this branch of engineering appears in a series of articles in the "Schweizerische Bauzeitung," and in view of the schemes which have recently been discussed, this review is of present value.

Pulverized fuel has been the subject of experiment since 1831, when Henschel, at Cassel, charged air with coal dust and used it for firing brick kilns, and for welding and for other smithy operations. Nearly thirty years later Pütsch attempted to use coal-dust firing for glass furnaces in England, and in the 70's Crampton made a number of applications of the principle to metallurgical operations.

In America the experiments of McAuley about 1881, and Hath-

away in 1886, are well known, and at the present time the experiences of Wegener and others in Germany and elsewhere are attracting considerable attention.

Three fundamental principles are laid down for the successful use of pulverized coal as fuel. (1) The combustion chamber must be maintained at a high temperature; (2) the powdered fuel must be delivered into the midst of the entering air current, and the intimate mixture of air and fuel delivered into the combustion chamber in an uninterrupted stream; (3) the particles of coal must be maintained suspended in the air until they are fully consumed.

This last condition is very important, since if the particles fall out of the air current to the bottom of the combustion chamber mere coking will take place instead of a complete combustion.

A distinction must be made between powdered fuel and the ordinary coal dust which is found at every mine. The coal for use in air-blast firing without grates must be finely ground in a mill, so that it will pass a sieve of 900 meshes per square centimeter, and must be entirely free from any larger particles.

The first of the above conditions requires especial consideration in connection with internally-fired boilers, since the proximity of boiler surface to the burning dust will chill the furnace to an extent sufficient to make the combustion imperfect. In order to avoid this it is necessary to line the furnace with fire brick, which, by attaining a high temperature, prevents the chilling of the flame and acts to equalize the temperature. There is no loss of heat by using such a lining, as the fire brick occupies only an intermediate position and the heat is ultimately transferred to the boiler surface.

The second condition, that of mixing the fuel with air and feeding the mixture into the combustion space, is the one which must be fulfilled by the construction of the apparatus, and the ingenuity of designers is mainly exerted in this direction.

The third condition is mainly dependent upon the fineness of pulverization, and it is the cost of grinding the coal to the necessary degree of fineness which usually limits the commercial application of any process.

The Wegener furnace, about which much has been said of late, is an attempt to apply pulverized coal methods similar to those which have been used successfully with low-grade hydrocarbons, and with petroleum refuse, in Russia. In this apparatus the finely-powdered coal is distributed into the incoming air by a revolving sieve, and the mixture is then driven into the combustion chamber by a steam jet. A firebrick lining permits the high temperature to be maintained, and as this soon becomes white hot, any slight inequality in the rate of firing does not permit a sudden chilling. The ash which exists in the coal is mostly fused to a liquid slag, which runs out a tap-hole below, and it is found that there is no greater accumulation of dust in the boiler flues than occurs with ordinary firing.

A number of tests, conducted with especial regard to smoke-prevention, have been made in Germany, and the details of these do not show any extraordinary evaporative performance, from 8 to 9 pounds of water per pound of coal being the average result. The absence of smoke was practically attained in all cases, however, whenever proper precautions were taken to provide sufficient fire-clay surface in the combustion chamber to prevent chilling of the flame. This has been found difficult of accomplishment in the case of water-tube boilers, unless an entirely separate combustion furnace is constructed, since the presence of the tubes containing water checks the combustion to an extent sufficient to cause smoke to be produced.

The use of pulverized fuel can hardly be recommended on the score of economy, as the evaporation is little if any higher than that obtained by ordinary firing, while at the same time the cost of grinding the coal must be included. When, however, it is imperative that no smoke be produced, it appears that this is one of the various methods by which that desirable result may be attained.

SMOKELESS COAL.—A "smokeless coal" of recent invention has just been tested in England. In the course of the experiments, which are described in "La Nature" (July 22), the new combustible "was burned in ordinary grates and also in braziers

placed in the middle of the room, and it was found that it gave off only traces of smoke, which was hardly perceptible even when fresh coal was added to the fire. The fire resembled an extraordinarily brilliant coke fire and had long white and blue flames. The heat given off is intense, and as to the production of steam, one pound of coal evaporates fourteen pounds of water. The residues (ashes, etc.,) do not exceed 3 per cent. For industrial use, the combustible is molded into perforated bricks weighing about ten pounds apiece, but for domestic use it takes the form of cakes or lumps of lenticular form, of which 140 weigh 100 pounds. At present the bricks can be bought in London at retail for 21s. ($5.25) a ton. We are told that the new combustible is composed of 93 per cent. of coal dust and of 7 per cent. of a mixture of pine and caustic lime. These three substances are mixed and run into molds, where they harden to such a degree that they do not separate in burning."—Translation made for "The Literary Digest."

WESTINGHOUSE BRAKE.—About a year since the Russian government determined to apply air brakes to freight trains upon the State railways. The Westinghouse Brake Company, Limited, of England, entered into negotiations with the Russian government with a view to furnishing the air-brake equipment; and when sufficient assurance of business was received, with the condition that the brakes should be made in Russia, a new company—the Société Anonyme Westinghouse—was formed, a manufacturing site in St. Petersburg was purchased, and the installation of manufacturing plant was begun. About the close of 1898, an order for air brakes, amounting in value to £400,000, was given to this new brake company by the Russian government. In January of the present year a congress of the engineers of all the private as well as all the Russian government railways was assembled, and, after due consideration, it was decided to adopt the Westinghouse brake system as the standard for all the private as well as the Imperial lines. On June 5 an Imperial decree was issued as follows: 1. All freight locomotives and tenders, and a sufficient number of freight cars to secure brake control of all

freight trains within the Russian Empire, must be equipped with air-brake apparatus prior to January 1, 1903. 2. The Westinghouse air brake has been adopted, and must be purchased for this purpose by all roads, private and State. 3. The use of any other kind or make of air brake than the Westinghouse is prohibited, with the provision, however, that a trial of any other brake system may be made in connection with the Westinghouse upon local lines.

JAPANESE BRIDGES.—The Pencoyd Iron Works of Philadelphia, has secured an order for a very large bridge for the Japanese Imperial government railways. The bridge will be 6,913 feet in length, and it will absorb between 7,000 and 7,500 tons of material.—"Engineering."

LIQUID FUEL.—The output of liquid fuel, or masut, and of petroleum by-products has now become the mainstay of the petroleum industry in Russia. The annual quantity of masut consumed amounts to no less than 500,000,000 poods, which, with the extension of the railways, is expected to further increase to a large extent. Not only in the firing of locomotive boilers liquid fuel is playing an important part, but also in connection with the raising of steam in marine boilers. As a preliminary, all the war vessels belonging to the Baltic fleet are now fired with liquid fuel, and it is believed the whole of the Russian Imperial navy will eventually be converted to the system, according to a gradual process of transformation. The industry is at present hampered through lack of a sufficient number of tank steamers.—"Marine Record."

CAST ALUMINUM is about equal in strength to cast iron in tension, while under compression it is comparatively weak. With a purity of 99 per cent. the ultimate tensile strength of aluminum per square inch is, in castings, 18,000 pounds; in sheet, 24,000 pounds to 40,000 pounds; wire, 30,000 pounds to 55,000 pounds; and in bars, 28,000 to 40,000 pounds. The elastic limit of aluminum of this purity is: for castings, 8,500 pounds; sheet, 12,500 to 25,000 pounds; wire, 16,000 to 33,000 pounds; and

bars, 14,000 to 23,000 pounds per square inch.—"Engineers' Gazette."

"THE ADVANTAGES OF THE USE OF GAS ENGINES can be best appreciated," says Mr. George Westinghouse, in a recent pamphlet entitled "Westinghouse Gas Engines," "when it is understood that if a gas company were to supplant the present gas illumination by an equal amount of electric light, obtained from gas engines and dynamos driven by its gas, it would have left for sale, for other purposes, over 60 per cent. of its present gas output."—"American Engineer and Railroad Journal."

SUPERHEATED STEAM offers a number of advantages which are summed up by Mr. R. S. Hale, in "The Engineering Magazine," as follows: 1st. A slight gain at the boiler, although a less gain than can be obtained by increasing the boiler-heating surface, or by the use of an economizer. 2d. A large gain in economy at the engine, while as a disadvantage there is: 3d. An increased loss in the steam pipes, due to increased radiation, fall of pressure and increased leaks. With from 500 to 700 degrees temperature of the steam, Mr. Hale places the results to be obtained as follows:

Gain at boiler, per cent	2
Gain at engine, per cent	10 to 20
Extra loss in pipes, per cent	4½
Net gain, per cent	7½ to 17½

—"American Engineer and Railroad Journal."

TIN.—In view of the increasing price of tin, it is interesting to learn that the Tasmanian exports of this metal had, up to the end of 1897, aggregated 80,000 tons, the Mount Bischof Mine being responsible for about three-sevenths of this total. This mine is worked in open quarry at three separate faces, known respectively as the Brown face, the Slaughter face, and the White face. The Brown face forms a semicircular quarry over 700 feet in length. The ore consists of brown oxide of tin, and has been proved to a depth of 260 feet. The Slaughter face is of similar

character, whilst the White face is an alluvial deposit.—"Engineering."

HOISTING ENGINES FOR MINES.—The enormous development of the copper mining industry in Northern Michigan has necessitated the adoption of very powerful hoisting engines, the depths being great and the load to be raised heavy. A fine engine of this character just erected at the Tamarack Mine by the Nordberg Manufacturing Company, of Milwaukee, is described in a recent issue of the "American Machinist." The engine is of the diagonal type, and has four cylinders, each 36 inches in diameter by 60 inches stroke, connected two and two on to two crank-pins. The main bearings are twenty-four inches in diameter by 42 inches long, and the drum is 25 feet in diameter and 24 feet 6 inches long, and is provided with spiral grooves for 1½-inch rope. These spirals are, however, only provided at the ends of the drum, since the depth of the shaft being 6,000 feet, a drum of an enormous size would have been needed to carry out the principle of the spiral drum in its entirety, and hence the middle portion of the drum is cylindrical. The total weight of the drum and shaft is 300,000 pounds. The load to be raised consists of 6,000 feet of 1½ rope, weighing 21,800 pounds, the cage weighing 4,200 pounds, two cars 4,000 pounds, and the rock mined 12,000 pounds, making a total of 42,000 pounds suspended on one rope. Part of this is, however, balanced by the descending cage. The speed of hoisting is 4,000 feet per minute. The engines are fitted with Corliss valves, the reversing gear being peculiar, but not easily explained without drawings.—"Engineering."

A HIGHLY SATISFACTORY TEST OF THE NEW 6-INCH QUICK-FIRING GUN, constructed for the American Navy by Messrs. Vickers, Sons and Maxim, has been made at the Indian Head proving ground. The first shots were fired with cordite, which in each instance gave velocities of 2,700 foot-seconds. After a sufficient number of rounds to demonstrate the fact that the velocities would exceed what was expected of the gun, Admiral O'Neill, chief of the United States Artillery Department, determined to

obtain a comparative result by using navy smokeless powder. Accordingly, he had employed a charge that would give a chamber pressure not exceeding 17 tons per square inch, and the result obtained under these conditions was a velocity of 2,913 foot-seconds; such a muzzle energy with the pressure employed has never before been obtained. In England, with the use of cordite, this gun gave a velocity of 2,873 foot-seconds, with a pressure of 17 tons. The projectiles fired weighed 100 pounds. A gas check was used and to a considerable extent accounts for the high energies obtained, and prevents any abnormal wear due to the use of modern gun-cotton or nitroglycerine explosives. The striking energy of the gun was no less than 5,724 foot-tons, which would perforate a thickness of steel armor of 17 inches. The energy obtained per ton of gun is 768.3 foot-tons, and as a rate of fire of ten pounds per minute for long series of rounds has been easily obtained, the gun is capable of doing work to no less extent than 57,240 foot-tons per minute. The gun and its naval mount has already been illustrated and described in "Engineering," vol. lxv, pages 624 and 625, and vol. lxvii, page 76.—"Engineering."

NEW STEEL PLANT.—The Carnegie Steel Company of Pittsburg have decided to build two more blast furnaces, at the Carrie plant at Rankin, Pa. These two furnaces will be the largest ever built, and will be 106 feet high and 24 feet in diameter at bosh. They will turn out 1,400 tons of Bessemer iron every day. A new bridge will be built from these furnaces across the Monongahela river, to take hot metal direct to the Homestead Steel Works. At Duquesne Steel Works a new basic open-hearth steel plant of fourteen 50-ton open-hearth furnaces and a large blooming mill are to be built. This mill will be one of the largest ever built, and will be a duplicate of the one just completed at Homestead Steel Works. These improvements and additions will give the Carnegie Steel Company a capacity for turning out over 3,000,000 tons of finished material annually. The open-hearth plant at Duquesne will be built to furnish the trade with basic open-hearth blooms, billets and slabs.—"The Iron Age."

SELF-STARTING SINGLE-PHASE MOTOR.—A patent was issued August 29 to Riccardo Arno, of Turin, Italy, on a means for dispensing with auxiliary starting coils on single-phase motors. The specification states that the inventor has discovered that by inserting an additional resistance into the closed-coil armature—that is, the rotor—and by imparting to the armature an initial motion of very slow speed, such as may be obtained by turning it by hand, asynchronous single-phase motors can be started without the use of a rotating magnetic field, and with only one group of coils—the mains coils—fed with current. The additional resistance must be capable of admitting of gradual reduction so as to be switched out gradually and without shocks just before the motor is gotten up to speed. Under these conditions it is stated that the strength of current during the whole period of starting will at no time exceed its strength just as the motor begins to turn. Trials carried out on large motors of 100 horsepower or more under no load, except the friction of the belt or loose pully, prove that the additional resistance to be inserted in the armature has a value which nearly corresponds to that required to absorb the effective current during the normal running of the motor under the same load. It is added that this condition is much more favorable than what takes place during the starting of asynchronous single-phase motors fed with auxiliary starting coils for the purpose of causing them to act as polyphase motors in getting up to synchronism. The theoretical value of the resistance to be inserted in the armature is $r = .414\ 2\pi\ n\ L$, n being the frequency and r and L the resistance and inductance, respectively, of each of the elementary armature coils. As illustrated there are three elementary armature coils, each connected to a collector ring on the shaft and, through its respective ring and brush, to a resistance adapted to be cut out by turning a three-armed lever on a rheostat, thereby gradually reducing, and finally short circuiting the resistances. To obviate the necessity of starting the rotor by means of an impluse given by the hand, means are shown whereby this can be accomplished simply by throwing in a switch, as follows: The rotor coils are rendered unsymmetrical at the instant of starting, which is done by switch-

ing one of the coils in open circuit, which will be sufficient to cause the starting of the machine provided it be not at a dead point, and the stopping of the machine at a dead point can always be avoided by a judicious operator. This process also affords a convenient means for reversing the direction of the motor.—"Electrical World and Engineer."

THE ORIENTAL DRY DOCK, at Shanghai, is now in operation. This dock has an extreme length of 540 feet, the entrance is 80 feet wide and the depth on sill is nearly 24 feet at ordinary spring tides. A wooden caisson gate is used. The bottom of the dock, 75 feet wide, is made of 7 feet of concrete, covered with 3-inch plank; the sides are also built of concrete. The dock can be pumped out in 2½ hours by two 27 and 22-inch centrifugal pumps driven by a compound engine. The North German Loyd steamship *Konigsberg* has already been docked here, with 2,500 tons of cargo aboard and imposing a total weight of over 7,000 tons on the keel blocks. The dock yard has a frontage of 2,000 feet, with a depth of 26 feet alongside, and the yard is already equipped with extensive shops fitted with modern machinery for repairs to hull, engines and boilers. On one side of the dry dock is installed a pair of steel sheerlegs with a lifting capacity of 75 tons.—"Engineering News."

WIRELESS TELEPHONY.—"Sir William H. Preece has recently been carrying on some interesting experiments on wireless telephony," so-called, says "The Scientific American" (October 7): "Four of the poles have been erected near Carnarvon on a sand bank at the southern end of Menai Straits. Half a mile off four similar poles were erected, and half a mile farther on is a high pole supporting a coil of wire, one end being anchored in deep water. Between these points he has succeeded in transmitting the sound of a succession of taps. These taps were made with the view of sending messages by the Morse mode. They were heard at the receiving station by placing a special telephone to the ear. The system is more rapid than that of Marconi, but the sounds are not as distinct as they might be. As a matter

of fact, it is not telephony at all, but a system of telegraphy in which a telephone is used as a receiver."

THE LABOR OF DISCOVERING A NEW ELEMENT.—What it means to discover a new chemical element in these days of minute and laborious physical investigation may be seen from the following description given by "The Imperial Institute Journal" (London), of the methods used by Sir William Crookes in bringing to light the substance announced by him last year and then called monium, but since named by him Victorium, in honor of England's queen. Says this paper:

"The method by which this latest discovery has been made affords an excellent example of the possibilities of modern research, especially in the hands of a man who commands the resources of more than one branch of science, and is able to employ the highest powers of each alternately as need arises. In addition to the chemical operations requiring the highest judgment and much manipulative skill, which were employed to isolate the substance, its identification and investigation were only possible by the application of physical methods still more complicated in their nature. The almost pure element had to be enclosed in a vacuous bulb, and submitted to molecular bombardment from the negative pole of an induction coil in the manner now familiar by the frequent exhibition of the X-ray bulb. The phosphorescent glow thus obtained was examined through a specially designed spectroscope of extreme power and precision, whose results were recorded by a photographic plate, the rays of special interest being in the ultra-violet part of the spectrum, and, therefore, invisible to the naked eye. For the examination of the negative so obtained a machine capable of measuring directly to the hundred-thousandth of an inch was specially constructed and applied. The pure substance itself was not used in the final investigations, the anhydrous sulphate being employed as obtained by heating the earth with strong sulphuric acid and driving off the excess of acid at red heat. For an account of the more distinctive chemical properties of the new element, the wave lengths of its distinctive rays when in a phos-

phorescent condition, and a detailed description of the two-prism spectrograph, reference must be made to the original paper in the Royal Society's proceedings. The diagram attached to the paper exhibits the process of fractional separation, and indicates that nearly one thousand distinct operations were necessary before the element was obtained in a comparatively pure condition."

DANGER FROM ELECTRIC SPARKS.—Any machine that is likely to give off electric sparks has been considered dangerous for use in localities where those sparks might ignite explosives or gas. "The Electrical Review" tells us, however, that motors have now been constructed that are absolutely free from sparking, so that they have even been installed in a powder mill. It says: "What a holding up of the hands in horror there would have been ten years ago if anybody had suggested electric motors as the prime movers of a powder mill! Yet the art of constructing these machines has advanced so far that the induction motor is to-day considered the safest power machine for such uses. The description of the new powder factory of the United States Navy Department is of interest in showing the feeling of safety that has been engendered by the perfection of the electrical transmission and distribution of power. The induction motor has been said to be 'as simple as a grindstone.' Likewise it is as sparkless as a waterwheel, and in a dangerous place like a powder factory as safe as a block of ice." Of interest along the same lines is the conclusion of two German experts, Herr Heise and Dr. Theim, that sparking machines or motors are especially dangerous in coal mines. It would seem, however, that in the case of motors this danger need no longer be feared; that is, if the confidence of those in charge of the Government powder factory is justified.—"The Literary Digest."

ELECTRIC WELDING OF RAILS.—Mr. R. F. Danforth, Superintendent of the International Traction Company, Buffalo, N. Y., at the Ithaca meeting of the Street Railway Association of the State of New York, stated:

"The Johnson Company has taken up the process of welding girder rails into continuous lengths, in the street. Its first method

of welding the abutting ends of rails by bringing the joint to a welding heat by the flow of an enormous current has been found to be a failure, because the homogeneity of the metal was destroyed. In the process of welding now being used in Buffalo, it has been the endeavor to follow as closely as possible the method employed in ordinary welding. After the metal is brought to a welding heat it is worked by being put under pressure of about 35 tons.

"Under the former process of electrically welding the ends of the rails together, the entire cross section of the rail had to be brought to a welding heat. In the process now in use the ball of the rail seldom reaches more than a dull red. It is believed that the quality of the steel in the rail head is not injured by this low temperature.

"In the true sense of the word, the abutting rails are not welded together, but the splice bars are welded to the web of the rail. These bars are of steel of the same quality as the rail, and measure 1 by 3 by 17 inches. The weld is made at three points, the center and ends of the bars. After the center weld is made, the ends of the bars are welded. The current flowing through the weld at five volts is about 30,000 ampères alternating. With this current flowing through the low-pressure secondary circuit, it is found necessary to cool the contacts by circulating water around them. It is found that the machine will average four joints an hour without any difficulty.

"You probably ask why we decided to use the welded joints. The reply is that we find that the welded joint not only solves the problem of maintaining a continuous rail, but also of the best return circuit. The carrying capacity of the bars as welded is greater than that of the rail itself; there is no opportunity for electrolytic action between two dissimilar metals; there are no expanded contacts to work loose and no added investment for copper. Another question frequently asked is, 'What do you do about expansion and contraction of your rail?' This is solved in two ways—first, by placing an expansion joint every 2,000 feet; second, by leaving the bolted joints at the special work.

"The cost of welded joints is not materially more than that of the bolted joint with ample bonding."

SHIPS.

UNITED STATES.

Denver Class—Cruisers 14-19.—Bids for the construction of these six sheathed cruisers were opened at the Navy Department November 1st. It is understood that the Board on Construction recommended acceptance of bids only on the Department plans, which are for ships of 16½-knots speed and about 3,200 tons displacement, with a coal capacity of 700 tons.

The awards were made on November 27th in accordance with the above recommendation, and secured to each of the following bidders one of these vessels:

Galveston, Wm. R. Trigg Co., 24 months, $1,027,000.
Chattanooga, Lewis Nixon, 30 months, $1,039,966.
Cleveland, Bath Iron Works, 30 months, $1,041,650.
Tacoma, Union Iron Works, 27 months, $1,041,900.
Des Moines, Fore River Engine Co., 30 months, $1,065,000.
Denver, Neafie & Levy S. & E. B. Co., 30 months, $1,080,000.
Making a total for the six ships of $6,295,516.

It is to be noted that the lack of evidence of ability to complete the ships within a reasonable stated time may militate against award to the lowest bidders on naval ships. This time element has heretofore been entirely too lightly dealt with, and the rule has been to have delivery made far after the contract time has expired—sometimes a year or more—and pleas in extension, of more or less plausibility, preventing infliction of penalties. As the number of competing builders increases, and the new plants become fully equipped for fast as well as thorough work, we can hope to have ships ready for commissioning at the expiration of the contract period.

The following are the bids for the Denver class:

I. Department Plans.

One vessel.		*Two vessels, each.*	
Townsend & Downey	$954,500	Townsend & Downey	$950,000
Wm. R. Trigg Co	1,027.000	Fore River Engine Co.	1,020,000
Lewis Nixon	1,039,966	Neafie & Levy	1,050,000
Bath Iron Works	1,041,650		
Union Iron Works	1,041,900		
Fore River Engine Co.	1,065,000		
Neafie & Levy	1,080,000		
Burlee Dock Co	1,105,000		
Columbian Iron Works	1,116,000		
Moran Bros. Co	1,122,000		

II. Builders' Plans.

Seventeen and one-half Knots.

One vessel.		*Two vessels, each.*	
Townsend & Downey	$1,059,500	Townsend & Downey	$1,055,000

III. *Eighteen Knots.*

One vessel.		*Two vessels, each.*	
Wm. R. Trigg Co. (Thornycroft boilers)	$1,041,000	Wm. R. Trigg Co. (Thornycroft boilers)	$993,700
Fore River Engine Co.	1,065,000	Fore River Engine Co.	1,020,000
Wm. R. Trigg Co. (B. & W. boilers)	1,073,000	Wm. R. Trigg Co. (B. & W. boilers)	1,024,700

IV. *Eighteen and one-half Knots.*

One vessel.		*Two vessels, each.*	
Fore River Engine Co.	$1,100,000	Fore River Engine Co.	$1,060,800

V. *Nineteen Knots.*

One vessel.		*Two vessels, each.*	
Wm. R. Trigg Co. (Thornycroft boilers)	$1,079,000	Wm. R. Trigg Co. (Thornycroft boilers)	$1,039,000

Kentucky.—This battleship, a sister ship to the *Kearsarge* (the trial of which is given so fully in this number of the JOURNAL), has also completed a very successful contract trial over the Cape Ann course, the runs having been made on November 24, under good circumstances of wind and weather. The sea was fairly smooth and the tide was not strong.

The ship entered the course for the first half of the trial at 10·27·45 A. M. of the day noted, and from the beginning the machinery and boilers functioned satisfactorily.

The throttle was carried wide open from start to finish, and the first receiver took live steam from the boilers continuously during both runs.

The oiling system operated satisfactorily, and with the arrangement of parts in this ship there is no difficulty in keeping in good and continuous touch with every journal and bearing. During a portion of the second half of the trial, which began at 12·42 P. M., the starboard feed heater gave out, presumably from split tubes, and the feed water was turned through the port heater exclusively. The feed left the hot wells at about 95 degrees Fahrenheit and entered the boilers at about 156 degrees Fahrenheit, showing a rise in temperature of some 61 degrees Fahrenheit.

During the turn between the first and second periods of the trial, from 12·25 P. M. to 12·42 P. M., the engines showed but little inclination to slow down from the rudder pressure.

Both engines ran at practically the same speed from end to end. The cut-offs were varied from .70 to .68 of the stroke, but for most of the time they were steady at .70.

No vibration at full speed could he detected in either engine room, and the absence of "panting" or apparent strain of the hull was a noticeable feature.

In all respects the engines came up to the expectations of the designers, and reflect equal credit upon the Bureau and upon the builders.

We are unable to secure the official data in time for this issue, but the reports will show that a somewhat greater power and speed were obtained than with the *Kearsarge*. The I.H.P. of main engines only was over 12,000, and, with an average of exactly 114 revolutions per minute, the speed (uncorrected) was 16⅞ knots per hour.

Dahlgren.—The contract trial of this torpedo boat took place off the Maine coast near Bath on October 27, and preliminary acceptance has been recommended. The trial was conducted on the standardized screw method, a speed-revolution curve having been established on October 23 by various runs over a measured mile, every means having been adopted by the trial board for securing the exact number of revolutions and the exact time for each run. Four double runs on the measured mile were thus made with the following results for standardization:

		1st double run.		2d double run.		3d double run.		4th double run.	
		N.	S.	N.	S.	N.	S.	N.	S.
		m. s.	*m. s.*	*m. s.*	*m. s.*	*m. s.*	*m. s.*	*m. s.*	*m. s.*
Duration of run		2 47.75	2 40	2 26.2	2 28.2	2 17	2 11.7	2 01.4	2 01
Speed of vessel in knots per hour		21.45	22.5	24.62	24.22	26.2	27 34	29.65	29.75
Total revolutions during run by counters,	Port	650	650	647	632	638	633	637	635
	Stb'd.	650	649	646	651.5	638	631	635	633
Revs. per minure, mean		233.9	243.6	265.3	259.8	278.6	287.9	314.3	314.4
Boiler steam gage in engine room at start,	Port	197	195	198	210	200	200	208	230
	Stb'd.	195	187	200	205	195	175	200	222
Vacuum	Port	24.5	26.5	26.5	27	27	26	27	27
	Stb'd.	25	25	26	25.5	25.5	26	26	26.6

The next day, October 24, the first attempt at a full-speed run on a straight course, was abruptly brought to a close by the bursting of a tube in the forward boiler. Just prior to this a run over the measured mile had been made in exactly two minutes, or at a rate of 30 knots per hour, and with a mean engine speed of 317 revolutions per minute.

On October 27, with weather conditions less favorable than obtained on the 23d, the full-power speed trial was made, resulting in an average of 318.08 revolutions per minute, for 60 consecutive minutes corresponding to 30.0075 knots per hour.

The *Dahlgren* is 147 feet long, 146.4 tons displacement, and contracted for 30.5 knots speed. The estimated I.H.P. for this is 4,200.

She has two Normand boilers, with total grate surface of 118.7 square feet, and heating surface of 5,552.4 square feet.

The bunker capacity is 32 tons, and an endurance at 10-knot speed calculated at nearly 1,500 knots.

The engines are twin, vertical, triple-expansion $\frac{17\frac{1}{4} \times 24\frac{3}{4} \times 37}{21}$ inches.

The mean pitch of the screws was ascertained to be 11.45 feet.

During the trial the speeds of the two engines were regulated according to the varying steam pressures by shifting the links. The engines worked very smoothly, without heating of any journal. No water was used externally on any journal or wearing surface. The feed pumps worked quite satisfactorily. There was practically no vibration of the engines, either in athwartships or fore-and-aft direction; only a slight panting of the bottom was observable. The working of the engines at the highest

speed indicated that they are well balanced, and that their framing is very stiff and their foundations strongly built. No foaming of boilers took place.

The fuel used on all the trial runs was a mixture of hand-picked Pocahontas and Kentucky Cannel coal, in the proportion of 40 pounds of Pocahontas to 35 pounds of Cannel coal, put up in bags weighing 75 pounds each.

The Cannel coal produced vast volumes of dense, black smoke, and with forced draft long sheets of dark red flame and a great quantity of burning embers issued from the chimney. Owing to the small height of the smoke pipes the smoke was driven down to the after part of the deck, making observations often very difficult.

No reliable information could be obtained of the actual amount of fuel consumed during the runs over the trial course.

During the full-power trial only four men were on duty in the engine room—two men attending to the throttle and cut-off gear of the two engines, and two men acting as oilers. The dynamo, kept running during the trial, was attended to by one of the oilers. One man on deck filled up the oil reservoirs from above. In the fire room one water tender, four firemen, two coal heavers and an additional man attending to the blower, were employed.

WEIGHT OF MACHINERY.

1. Engines, shafting, etc. (not including water), abaft forward engine-room bulkhead, pounds	90,882
2. Boilers, etc. (not including water), forward of forward engine-room bulkhead, pounds	65,797
3. Spare parts and outfit, pounds	2,193
4. Water in condensers, pumps and piping, etc., abaft forward engine-room bulkhead, pounds (442 pounds of water in scoops and stern tubes included)	5,234
5. Water in boilers, pumps and piping forward of forward engine-room bulkhead, pounds	14,711
6. Water in reserve feed tanks (⅔ capacity of tanks), pounds	8,760
Total pounds	187,577

Charleston.—The following dispatch reporting the wreck of this cruiser was received at the Navy Department on November

14th, and was one of those startling announcements for which, since the cessation of the Spanish war, the public ear no longer listened. More recent news states that the ship has entirely disappeared, and the only consoling feature is that the casualty was not attended with loss of life:

"MANILA, *November 13, 1899.*

"SECRETARY OF THE NAVY, Washington:

"*Charleston* wrecked on uncharted coral reef, three miles northwest of Guinapak Rocks, north coast of Luzon, at 5·30 on the morning of November 2. Everybody safely landed at Kamiguin Island, armed with rifles and two Colts. The natives friendly. McDonald made Lingayen gulf in a sailing launch. When he left there was no opportunity of examining condition of wreck. Northeast monsoon and heavy sea prevailing. Reports ship struck easily, then thumped violently. Fire-room compartments flooded. First watertight doors closed promptly. Ship lies settled aft; water one foot from name; well out of water forward. Apparently very steep bank. Ten days' provisions, half rations, landed. *Helena* dispatched from Lingayen by *Oregon* to Kamiguin; due to-day.

"WATSON."

The list of officers on board the *Charleston* is as follows: Captain George W. Pigman, commanding; Lieutenant Commander John A. Norris, Lieutenant Commander W. N. Little (engineer), Lieutenant John A. Dougherty, Lieutenant Louis S. Van Duzer, Lieutenant John D. McDonald, Lieutenant (junior grade) De Witt Blamer, Ensign Ivan C. Wettengel, Ensign James B. Henry, Jr., Naval Cadet John A. Schofield, Naval Cadet Charles B. Hatch, Surgeon Charles T. Hibbett, Assistant Surgeon Edward V. Armstrong, Paymaster Z. B. Reynolds, First Lieutenant George C. Thorpe, U. S. M. C.; Boatswain Dominick Flynn, Gunner Joseph R. Ward, Carpenter John H. Gill, Acting Warrant Machinist Benjamin F. Beers, Acting Warrant Machinist Joseph Wilson, Pay Clerk R. J. Little.

The *Charleston* is one of the older vessels of the new Navy. She is included in the group of vessels following the completion of the cruisers *Chicago*, *Boston*, *Atlanta* and *Dolphin*, built in 1882

and 1883, which were the pioneers of the present Navy. The *Charleston* was a steel protected cruiser built by the Union Iron Works at San Francisco, her keel being laid in the year 1887. The contract price of her hull and machinery was $1,017,500. She was launched in July, 1888, and placed in commission for the first time in December, 1889. The ordnance bureau of the Navy has been busy for some time past making extensive alterations in the battery of the *Charleston*, and had these been completed the ship would have been brought thoroughly up to date. She was 312 feet 7 inches long, 46 feet 2 inches beam, and 18 feet 7 inches draught, with a displacement of 3,730 tons. She had twin-screw compound engines, inclined 7 degrees 21 minutes from horizontal and rated at 6,666 I.H.P. at 18.2 knots.

She carried in her main battery six 6-inch guns and two 8-inch guns. Her secondary battery consisted of four 6-pounders, two 3-pounders, two 1-pounders, four 37-millimeter guns, two machine guns and two field pieces. Her complement for a crew was 300 men. She had also four torpedo tubes, and was rigged with two masts, each of which carried a military top. She had one funnel, and her normal coal capacity was 328 tons, and she could run 805 knots at her maximum speed. She could carry 800 tons of coal and steam 2,012 knots at her maximum speed, or 7,476 knots at a 10-knot rate.

U. S. S. Alabama.—The preliminary builder's trial of the U. S. battleship *Alabama*, constructed by the Cramps, was held in September last, and a statement made that she maintained an average speed in excess of . knots. The vessel is incomplete, as the side armor of Harveyized nickel-steel is not yet in place. The regular contract trial has been delayed, owing to labor strike at the Cramps, and no data of importance can be obtained regarding actual performance until this trial does take place. The *Alabama* was authorized by Act of Congress passed in June, 1896, which also called into being the battleship *Illinois*, building at Newport News, Va., and the battleship *Wisconsin*, building at the Union Iron Works, San Francisco. She is practically ready for service, with the important exception of her armor, the delay in this being caused by the armor-plate dispute.

Launch of the Shubrick.—That a torpedo boat should be built in the City of Richmond, Va., and launched into the James is not of itself remarkable, but those persons who, on October 31, witnessed the launching of the *Shubrick* at the works of the Wm. R. Trigg Co., can safely say that the occasion was second to none as regards the eminence of the principal participators, the enthusiasm of the local populace and the completeness of the arrangements for the event. Indeed, no battleship was ever launched with greater éclat or success.

The President of the United States with the members of his Cabinet was the official and social feature of the day, and the welcome accorded the Chief Magistrate was highly complimentary and delightful. Mayor Taylor, of the City of Richmond, and Governor Tyler and former Governor Fitzhugh Lee, of the State of Virginia, were additional stars in the gathering, while the Navy was represented not only by Secretary Long, but by a number of officers, headed by Rear Admiral Melville.

Colonel Triggs' profusive liberality in providing for his host of guests was everywhere in evidence, and the Naval contingent was especially fortunate in being under the wing of Lieutenant W. Strothers Smith, U. S. Navy, inspector of the *Shubrick*. Lieutenant Smith represented Colonel Trigg in taking charge of the arrangements for their comfort, and it is to his genial personality and energetic efforts that the faultless consummation of this part of the programme is due.

The launch was a *side* launch, not common with our Naval vessels, but here, in every way, a successful and picturesque one.

The President made a very felicitous speech, followed by the other most prominent personages, and at four o'clock the little vessel was launched, being christened by Miss Carrie Shubrick, the young granddaughter of Commodore Shubrick, for whom the boat was named.

The *Shubrick* is of the following dimensions: Length, 175 feet; beam, 17 feet; draught, 4 feet 8 inches; displacement on trial, 165 tons; speed expected on trial, 26 knots. The engines are vertical, four-cylinder triple-expansion type of the following size: Diameter of H.P. cylinder, 14 inches; diameter of I.P. cylinder,

22 inches; diameter each L.P. cylinder, 25¼ inches; stroke of engine, 18 inches. She will have three Thornycroft boilers with total grate area of 136.8 square feet; heating surface, 7,548 square feet. The indicated I.H.P. at 350 revolutions per minute is calculated at 3,000, the boiler pressure being 250 pounds per square inch.

The bunker capacity is about 70 tons. She will be lighted throughout by electricity and furnished with one searchlight of an approved pattern. There will be two conning towers, the forward one to be of one-half inch nickel-steel plates.

The battery will be composed of three rapid-firing guns and mounts, weighing about two tons, with three and a half tons of ammunition. There will be mounted on deck, in approved positions, three 15-foot torpedo tubes, with torpedoes and storage space below for two additional torpedoes and five war heads. All ordnance weights will amount in total to about thirteen tons.

Berthing space will be provided for a crew of twenty-six men and three officers and provision space for twenty days. The concontract price for the *Shubrick* is $129,750.

The Holland Submarine Boat was tested on November 7 by the Board of Survey and Inspection of the U. S. Navy Department, Rear Admiral Frederick Rogers, chairman. The test was made off Greenport, L. I., in water 20 feet deep. The run of one measured mile, submerged 10 feet below the surface, was made in 9 minutes; the *Holland* then rose, discharged a Whitehead torpedo and disappeared in 10 seconds. The torpedo weighed 840 pounds, and was discharged from the bow tube, and at a range of 400 feet it passed within 25 feet of the target flag; the torpedo had no war head and traveled 800 feet. The *Holland* then turned under water in one and a half times her own length, of 54 feet. With decks awash and against a strong ebb tide she made 8 knots speed. The Board expressed itself, unofficially, as surprised and delighted with the success of the trial in all requirements. The *Holland* was built in 1896 at the Nixon shipyard, and cost about $300,000; but she could be duplicated for about half that sum. She is 54 feet long, cylindrical in cross-section, and 9 feet in diameter amidships. It is the sixth boat

built by Mr. John P. Holland, and the present craft will be taken to Washington in a few days for further inspection. She will make the trip through the Raritan Canal, and be lightened to 8 feet by pontoons.

Alphabetical List of Vessels of the United States Navy, December 1, 1899.

Name.	*Type.*	*Displacement, tons.*	*Present station or condition.*
Aberenda	Collier	4,670,	Samoan Islands.
Accomac	Tug	187,	Havana.
Active	Tug	296,	Mare Island.
Adams	Cruiser, wood	1,400,	Training Ship. Pacific.
Aileen	Yacht,	192,	Naval Reserve, New York.
Alabama	Battleship	11,525,	Cramps. Nearly completed.
Albany	Protected Cr	3,437,	England. Nearly completed.
Albay	Gunboat	100,	Asiatic Station.
Alert	Cruiser	1,020,	Out commiss'n. Mare Island.
Alexander	Collier	6,181,	Asiatic Station.
Alice	Tug	356,	Out commission. Norfolk.
Alliance	Cruiser, wood	1,375,	Training ship.
Alvarado	Gunboat	108,	Out commiss'n. Portsmouth.
Amphitrite	Monitor	3,990,	New York.
Annapolis	Gunboat	1,000,	Out commission. Annapolis.
Apache	Tug	650,	Norfolk.
Arethusa	Tank steamer	6,000,	Out commiss'n. Mare Island.
Arkansas	Monitor	3,235,	Bldg. Newport News.
Atlanta	Protected Cr	3,000,	Repairing. New York.
Badger	Auxiliary Cr	4,784,	Out commiss'n. Mare Island.
Bagley	Torpedo boat	167,	Bldg. Bath Iron Works.
Bailey	Torpedo boat	250,	Bldg. Gas Eng. & Power Co.
Bainbridge	T-B. destroyer	420,	Bldg. Neafie & Levy Works.
Balanga	——	——,	Asiatic Station.
Baltimore	Protected Cr	4,403,	Asiatic Station.
Bancroft	Gunboat	839,	Out commission. Boston.
Barcelo	Torpedo boat	——,	Asiatic Station.
Barney	Torpedo boat	167,	Bldg. Bath Iron Works.
Barry	T-B. destroyer	420,	Bldg. Neafie & Levy Works.
Belusan	Gunboat	——,	Repairing. Asiatic Station.
Bennington	Gunboat	1,710,	Asiatic Station.
Biddle	Torpedo boat	167,	Bldg. Bath Iron Works.
Blakely	Torpedo boat	165,	Bldg. Bath Iron Works.
Boston	Protected Cr	3,000,	Out commiss'n. Mare Island.
Brooklyn	Armored Cr	9,215,	En route to Asiatic Station.
Brutus	Collier	5,800,	Guam.

Name.	Type.	Displacement, tons.	Present station or condition.
Buffalo	Auxiliary Cr.	6,000,	Out commission. New York.
Caesar	Collier	5,016,	San Juan.
California	Armored Cr.	12,000,	Contract not yet awarded.
Callao	Gunboat	246,	Asiatic Station.
Canonicus	Monitor	2,108,	Laid up. League Island.
Cassius	Collier	7,000,	Out commission. Norfolk.
Castine	Gunboat	1,177,	Asiatic Station.
Catskill	Monitor	1,875,	Laid up. League Island.
Celtic	Supply ship	6,428,	Asiatic Station.
Charleston	Protected Cr.	3,730,	Wrecked in Philippines.
Chattanooga	Protected Cr.	3,200,	Bldg. Crescent Shipyard.
Chauncey	T-B. destroyer	420,	Bldg. Neafie & Levy Works.
Chesapeake	Training ship	1,175,	Boston. Nearly completed.
Cheyenne	Tug	220,	Out commission. Port Royal.
Chicago	Protected Cr.	4,500,	S. Atlantic Station. En route.
Chickasaw	Tug	140,	Out commission. Port Royal.
Choctaw	Tug	200,	Newport, R. I.
Cincinnati	Protected Cr.	3,200,	Out commission. New York.
Cleveland	Protected Cr.	3,200,	Bldg. Bath Iron Works.
Columbia	Protected Cr.	7,375,	Out comm'n. League Island.
Concord	Gunboat	1,710,	Asiatic Station.
Connecticut	Monitor	3,235,	Bldg. Bath Iron Works.
Constellation	Sailing ship	1,186,	Training ship. Newport.
Constitution	Sailing ship	2,241,	Out commission. Boston.
T. A. M. Craven	Torpedo boat	146.4,	Bldg. Bath Iron Works.
Culgoa	Supply ship	4,500,	Asiatic Station.
Cushing	Torpedo boat	105,	Out commission. New York.
Dahlgren	Torpedo boat	146.4,	Bldg. Bath Iron Works.
Davis	Torpedo boat	132,	Out comm'n. Mare Island.
Dale	T-B. destroyer	420,	Bldg. Wm. R. Trigg Co.
Dale	Sailing ship	675,	Naval Militia, Maryland.
Decatur	T-B. destroyer	420,	Bldg. Wm. R. Trigg Co.
DeLong	Torpedo boat	165,	Bldg. Fore River Engine Co.
Denver	Protected Cr.	3,200,	Bldg. Neafie & Levy.
Des Moines	Protected Cr.	3,200,	Bldg. Fore River Co.
Detroit	Unprotected Cr.,	2,089,	North Atlantic Station.
Dixie	Auxiliary Cr.	6,145,	League Island.
Dolphin	Despatch boat	1,486,	Special duty.
Don Juan de Austria,	Gunboat	1,159,	Asiatic Station.
Dorothea	Yacht	594,	Out commission. Norfolk.
DuPont	Torpedo boat	165,	Newport.
Eagle	Yacht	434,	North Atlantic Station.
El Cano	Gunboat	560,	Repairing. Asiatic Station.
Elfrida	Yacht	173,	Port Royal.
Enterprise	Cruiser, wood	1,375,	Training ship, State of Mass.

Name.	Type.	Displacement, tons.	Present station or condition.
Ericsson	Torpedo boat	120,	Out commission. New York.
Essex	Cruiser, wood	1,375,	Training ship.
Farragut	Torpedo boat	273,	Mare Island.
Fern	Tug	340,	Naval Militia, Washington.
Florida	Monitor	3,235,	Bldg. Lewis Nixon's Works.
Foote	Torpedo boat	142,	Out commission. New York.
Fortune	Tug	450,	Repairing. Norfolk.
Fox	Torpedo boat	132,	Mare Island.
Franklin	Frigate, wood	5,170,	Receiving ship. Norfolk.
Frolic	Yacht	607,	Out commission. Norfolk.
Galveston	Protected Cr	3,200,	Bldg. Wm. R. Trigg Co.
Georgia	Battleship	13,500,	Contract not yet awarded.
Glacier	Refrigerat'g shp.	—— ,	Asiatic Station.
Gloucester	Yacht	786,	Out commission. Annapolis.
Goldsborough	Torpedo boat	247.5,	Wolf & Zwicker. Nearly com.
Guardoqui	Gunboat	42,	Asiatic Station.
Gwin	Torpedo boat	45.78,	North Atlantic Station.
Hannibal	Collier	4,291,	Out commission. Norfolk.
Hartford	Cruiser, wood	2,790,	Mare Island.
Hawk	Yacht	375,	Out commission. Norfolk.
Helena	Gunboat	1,392,	Asiatic Station.
Hercules	Tug	198,	Port Royal.
Hist	Yacht	770,	Norfolk.
Hopkins	T-B. destroyer	408,	Bldg. Harlan & Hollingsworth.
Hornet	Yacht	425,	Naval Militia, North Carolina.
Hull	T-B. destroyer	408,	Bldg. Harlan & Hollingsworth.
Huntress	Yacht	82,	Naval Militia, New Jersey.
Illinois	Battleship	11,525,	Bldg. Newport News.
Inca	Yacht	—— ,	Naval Militia, Massachusetts.
Independence	Sailing ship	3,270,	Receiving ship. Mare Island.
Indiana	Battleship	10,810,	North Atlantic Station.
Iona	Launch	—— ,	Asiatic Station.
Iowa	Battleship	11,340,	San Francisco.
Iris	Distilling ship	6,100,	Asiatic Station.
Iroquois	Cruiser	1,575,	Marine Hospital Service.
Iroquois	Tug	702,	Honolulu.
Isla de Cuba	Gunboat	1,130,	Asiatic Station.
Isla de Luzon	Gunboat	1,130,	Asiatic Station.
Iwana	Tug	192,	Boston.
Jamestown	Sail. ship, wood,	1,150,	Marine Hospital Service.
Jason	Monitor	1,875,	Laid up. League Island.
Justin	Collier	3,300,	Out commission. Mare Island.
Kanawha	Yacht	175,	Naval Militia, Rhode Island.
Katahdin	Ram	2,155,	Out commission. League Island.
Kearsarge	Battleship	11,525,	Not completed. Newport News.

Name.	Type.	Displacement, tons.	Present station or condition.
Kentucky	Battleship	11,525,	Not completed. Newport News.
Lancaster	Cruiser, wood	3,250,	Gunnery training ship.
Lawrence	T-B. destroyer	400,	Bldg. Fore River Engine Co.
Lebanon	Collier	3,375,	Out commission. League Island.
Lehigh	Monitor	1,875,	Laid up. League Island.
Leonidas	Collier	4,242,	Out commission. League Island.
Leyden	Tug	450,	Newport, R. I.
Leyte	Gunboat	150,	Asiatic Station.
Machias	Gunboat	1,177,	North Atlantic Station.
Macdonough	T-B. destroyer	400,	Bldg. Fore River Engine Co.
Mackenzie	Torpedo boat	65,	Newport, R. I.
Mahopac	Monitor	2,100,	Laid up. League Island.
Maine	Battleship	12,500,	Bldg. Cramps.
Manhattan	Monitor	2,100,	Laid up. League Island.
Manila	Transport	1,900,	Asiatic Station.
Manileno	Gunboat	142,	Asiatic Station.
Manly	Torpedo boat	——,	Out commission. Annapolis.
Marblehead	Unprotected Cr.,	2,037,	Pacific Station.
Marcellus	Collier	——,	Out commission. New York.
Marietta	Gunboat	1,000,	Asiatic Station.
Marion	Wooden vessel	1,900,	Naval Militia, California.
Mariveles	Gunboat	142,	Asiatic Station.
Massachusetts	Battleship	10,810,	North Atlantic Station.
Massasoit	Tug	202,	Naval Station, Key West.
Mayflower	Yacht	2,690,	Out commission. New York.
McKee	Torpedo boat	65,	Out commission. New York.
Miantonomoh	Monitor	3,990,	Out commission. League Island.
Michigan	Iron Cr.	685,	On the Great Lakes.
Mindanao	Gunboat	83,	Asiatic Station.
Mindoro	Gunboat	142,	Asiatic Station.
Minneapolis	Protected Cr.	7,375,	Out commission. League Island.
Minnesota	Cruiser, wood	4,700,	Out commission. Boston.
Missouri	Battleship	12,500,	Bldg. Newport News.
Modoc	Tug	241,	League Island.
Mohawk	Tug	420,	League Island.
Mohican	Cruiser, wood	1,900,	Training ship. Mare Island.
Monadnock	Monitor	3,990,	Asiatic Station.
Monocacy	Unprotected Cr.,	1,370,	Asiatic Station.
Monongahela	Sail. ship, wood,	2,100,	Training ship. New York.
Montauk	Monitor	1,875,	Laid up. League Island.
Monterey	Monitor	4,084,	Asiatic Station.
Montgomery	Unprotected Cr.,	2,089,	South Atlantic Station.
Morris	Torpedo boat	104.75,	Newport, R. I.
Nahant	Monitor	1,875,	Laid up. League Island.
Nanshan	Collier	——,	Asiatic Station.

Name.	*Type.*	*Displacement, tons.*	*Present station or condition.*
Nantucket	Monitor	1,875,	Out commission. Port Royal.
Narkeeta	Tug	192,	New York.
Nashville	Gunboat	1,370,	Asiatic Station.
Nebraska	Auxiliary Cr.	12,000,	Contract not yet awarded.
Nero	Collier	4,925,	Asiatic Station.
Newark	Protected Cr.	4,098,	Asiatic Station.
New Hampshire	Sail. ship, wood,	4,150,	New York Naval Militia.
New Jersey	Battleship	13,500,	Contract not yet awarded.
New Orleans	Protected Cr.	3,437,	Asiatic Station.
Newport	Gunboat	1,000,	Out commission. Norfolk.
New York	Auxiliary Cr.	8,200,	North Atlantic Station.
Nezinscot	Tug	156,	Out commission. Norfolk.
Nicholson	Torpedo boat	174,	Bldg. Crescent Ship Yard.
Nina	Tug	357,	New York.
Nipsic	Wooden vessel	1,375,	Naval Station, Puget Sound.
O'Brien	Torpedo boat	174,	Bldg. Crescent Ship Yard.
Ohio	Battleship	12,500,	Bldg. Union Iron Works.
Olympia	Protected Cr.	5,570,	Out commission. Boston.
Omaha	Cruiser, wood	2,400,	Marine Hospital Service.
Ondina	Launch	——,	Asiatic Station.
Oneida	Yacht	150,	Out commission. Norfolk.
Oregon	Battleship	10,288,	Asiatic Station.
Osceola	Tug	571,	Out commission. Norfolk.
Pampango	Gunboat	201,	Asiatic Station.
Panay	Gunboat	142,	Asiatic Station.
Panther	Auxiliary Cr.	4,260,	Out commission. League Island.
Paragua	Gunboat	201,	Asiatic Station.
Passaic	Monitor	1,875,	Out commission. League Island.
Paul Jones	T-B. destroyer	420,	Bldg. Union Iron Works.
Pawnee	Tug	275,	New York.
Pawtucket	Tug	225,	Puget Sound Station.
Penacook	Tug	225,	Naval Station, Port Royal.
Pennsylvania	Battleship	13,500,	Contract not yet awarded.
Pensacola	Cruiser, wood	3,000,	Receiving ship. San Francisco.
Peoria	Gunboat	488,	Out commission. Boston.
Perry	T-B. destroyer	420,	Building. Union Iron Works.
Petrel	Gunboat	892,	Asiatic Station.
Petrelito	Tug	——,	Asiatic Station.
Philadelphia	Protected Cr.	4,324,	Mare Island.
Pinta	Gunboat	550,	Naval Militia. California.
Piscataqua	Tug	850,	Portsmouth.
Plunger	Submarine T-B.,	168,	Bldg. Columbian Iron Works.
Pompey	Collier	——,	Out commission. League Island.
Pontiac	Tug	400,	Laid up. Boston.
Porter	Torpedo boat	165,	North Atlantic Station.

Name.	*Type.*	*Displacement, tons.*	*Present station or condition.*
Portsmouth	Sail. ship, wood..	1,125,	Naval Militia. New Jersey.
Potomac	Tug	667,	North Atlantic Station.
Powhatan	Tug	194,	Pensacola.
Prairie	Auxiliary Cr	6,872,	Naval Reserve.
Preble	T-B. destroyer	420,	Bldg. Union Iron Works.
Princeton	Gunboat	1,000,	Asiatic Station.
Puritan	Monitor	6,060,	Out commission. Annapolis.
Rainbow	Distilling ship	6,206,	Out commission. New York.
Raleigh	Protected Cr	3,213,	Out commission. Portsmouth.
Ranger	Unprotected Cr.,	1,020,	Mare Island.
Rapido	Tug	137,	Asiatic Station.
Reina Mercedes	Unprotected Cr.,	3,090,	Out commission. Norfolk.
Resolute	Transport	4,175,	North Atlantic Station.
Restless	Yacht	——,	Out commission. New York.
Richmond	Cruiser, wood	2,700,	Receiving ship. League Island.
Rocket	Tug	187,	Boston.
Rodgers	Torpedo boat	142,	Out commission. New York.
Rowan	Torpedo boat	182,	Out commission. Puget Sound.
Samar	Gunboat	200,	Asiatic Station.
Samoset	Tug	225,	League Island.
Sandoval	Gunboat	100,	Out commission. Portsmouth.
San Francisco	Protected Cr	4,098,	Out commission. Norfolk.
Saratoga	Sail. ship, wood,	1,025,	School ship. State of Penna.
Saturn	Collier	6,220,	Out commission. Norfolk.
Scindia	Collier	7,500,	Mare Island.
Scorpion	Yacht	850,	North Atlantic Station.
Seminole	Tug	——,	Out commission. Boston.
Shearwater	Yacht	122,	Naval Militia. Pennsylvania.
Shubrick	Torpedo boat	165,	Bldg. Wm. R. Trigg Co.
Sioux	Tug	155,	Norfolk.
Siren	Yacht	315,	Out commission. Norfolk.
Solace	Hospital ship	4,700,	Asiatic Station.
Somers	Torpedo boat	145,	Out commission. New York.
Southery	Collier	3,100,	Out commission. Norfolk.
Standish	Tug	450,	Annapolis.
Sterling	Collier	5,663,	Out commission. Boston.
Stewart	T-B. destroyer	420,	Bldg. Gas Engine & Power Co.
Stiletto	Torpedo boat	31,	Newport, R. I.
St. Louis	Sail. ship, wood,	830,	Naval Militia, Pennsylvania.
St. Mary's	Sail. ship, wood,	1,025,	School Ship. New York.
Stockton	Torpedo boat	165,	Bldg. Wm. R. Trigg Co.
Stranger	Yacht	546,	Naval Militia, Louisiana.
Stringham	Torpedo boat	340,	About completed, Harlan & Hollingsworth.
Supply	Supply ship	4,670,	North Atlantic Station.

Name.	*Type.*	*Displacement, tons.*	*Present station or condition.*
Sureste	Tug	—?	—, Asiatic Station.
Sylph	Yacht	152	Special duty. Washington.
Sylvia	Yacht	302	Naval Militia. Maryland.
Tacoma	Protected Cr	3,200	Bldg. Union Iron Works.
Tacoma	Tug	——	Pensacola.
Talbot	Torpedo boat	46.5	Norfolk.
Tecumseh	Tug	214	Out commission. Washington.
Terror	Monitor	3,990	Out commission. Washington.
Texas	Battleship	6,315	North Atlantic Station.
Thornton	Torpedo boat	165	Bldg. Wm. R. Trigg Company.
Tingey	Torpedo boat	165	Bldg. Col. Iron Works, Baltimore.
Topeka	Gunboat	1,700	Out commission. Boston.
Traffic	Tug	280	New York.
Triton	Tug	212	Repairing. Norfolk.
Truxtun	T-B. destroyer	433	Bldg. Maryland Steel Co.
Unadilla	Tug	345	Mare Island.
Uncas	Tug	441	San Juan, Porto Rico.
Urdaneta	Gunboat	42	Asiatic Station.
Vasco	Gunboat	42	Asiatic Station.
Vermont	Sail. ship, wood,	4,140	Receiving ship. New York.
Vesuvius	Dynamite Cr	929	Out commission. Boston.
Vicksburg	Gunboat	1,000	Out commission. Boston.
Vigilant	Tug	300	Mare Island.
Viking	Yacht	218	Out commission. Norfolk.
Vixen	Yacht	806	Norfolk.
Waban	Tug	——	Port Royal, S. C.
Wabash	Wooden vessel	4,650	Receiving ship. Boston.
Wahneta	Tug	192	Norfolk.
Wasp	Yacht	630	Naval Militia. Florida.
West Virginia	Armored Cr	12,000	Contract not yet awarded.
Wheeling	Gunboat	1,000	Asiatic Station.
Whipple	T-B. destroyer	433	Bldg. Maryland Steel Co.
Wilkes	Torpedo boat	165	Bldg. Gas Engine & Power Co.
Wilmington	Gunboat	1,392	South Atlantic Station.
Winslow	Torpedo boat	142	Newport, R. I.
Wisconsin	Battleship	11,525	Bldg. Union Iron Works.
Wompatuck	Tug	462	New York.
Worden	T-B. destroyer	433	Bldg. Maryland Steel Co.
Wyoming	Monitor	3,235	Bldg. Union Iron Works.
Yankee	Armored Cr	6,000	Out commission. League Island.
Yankton	Yacht	975	North Atlantic Station.
Yantic	Wooden vessel	900	Naval Militia. Michigan.
Yorktown	Gunboat	1,710	Asiatic Station.
Yosemite	Armored Cr	6,145	Guam.
Zafiro	Supply ship	——	—, Asiatic Station.

DENMARK.

Herluf Trolle.—On Saturday, Sept. 2, there was launched from the Royal Dockyards at Copenhagen, in the presence of the King of Denmark, the Princess of Wales, and a most illustrious gathering, the new Danish warship, the *Herluf Trolle*. Her displacement is 3,470 tons, length, about 271 feet; breadth, 50 feet, and depth in water, about 16.12 feet. She will have two propellers. The engines are calculated at 4,200 indicated horsepower, and the maximum speed at 15 knots. The armament will consist of two 24-centimeter breech-loading guns from Canet, placed in the turret; four 150-millimeter rapid-firing guns, manufactured at Bofors, Sweden, and placed in the protected corners of the deckhouse; ten 57-millimeter rapid-firing guns, made in Denmark, and eight lighter guns. There are three submarine torpedo-firing appliances, one in the bows and two at the sides. The *Herluf Trolle* is built of steel, with double bottom and numerous watertight compartments; the perpendicular side armor extends from about 3 feet above the water line to the same distance below, and its thickness decreases towards the ends. The side armor ceases about 20 feet from the bows, and the ends of the side armor are connected by means of an armored bulkhead, from which an armored deck proceeds below water to the spur. The ship is fitted with armored deck and all modern appliances.

ENGLAND.

London.—This battleship was launched at Portsmouth on the 21st instant, by Lady George Hamilton. The displacement of the *London* at the time of taking the water was about 5,000 tons, including the launching ways, but when completed she will displace 15,000 tons. The new vessel is of the following dimensions: Length between perpendiculars, 400 feet; extreme breadth, 75 feet; draught forward, 26 feet 3 inches; aft, 27 feet 3 inches. Her inverted, vertical, triple-expansion engines, made by the Earle Company, of Hull, will have an indicated horsepower of 15,000; her boilers are of the Belleville type. Her speed will be 18 knots, and her coal stowage 2,040 tons. The complement of the great vessel, when she is ready for sea, will be 773 persons, ex-

clusive of an admiral and his staff, if carried, for whom accommodation is provided.

The armament of the *London* will consist of four 12-inch, breech-loading wire guns, twelve 6-inch quick-firing guns, sixteen 12-pounder quick-firing guns, weighing 12 cwt. each, two 12-pounder quick-firing guns, weighing 8 cwt. each, for boat use, six 3-pounder quick-firing guns, and eight .45-inch Maxims. Four submerged torpedo tubes and fourteen 18-inch and five 14-inch torpedoes complete her powers of offense. The thickness of the armor plating in various parts is thus described: For 216 feet of the sides, 9 inches, tapering beyond this length towards the bow to 2 inches; on bulkheads, 12 inches, 10 inches and 9 inches; on barbettes, 12 inches, 10 inches and 6 inches; on casemates, 6 inches; on fore conning tower, 14 inches, with 8-inch communication tubes; on the after conning tower, 3 inches, with 3-inch communication tubes; on the twelve gun shields, 8 inches and 10 inches; on the roof and floor of the same, 3 inches of Harveyed nickel-steel. The following are the particulars of the protective-deck plating: Middle deck between armor bulkheads, two thicknesses of 1 inch, with an extra thickness of 1 inch on the slopes over the machinery spaces; lower deck before forward armor bulkhead, two thicknesses of 1 inch; lower deck abaft after armor bulkhead, two thicknesses of 1 inch and ½ inch respectively; main deck between armor bulkheads, two thicknesses of ½ inch.

The *London* will have two steel masts, each fitted with a military or fighting top, and with a searchlight platform on the main topmast, and a long-distance semaphore for signaling at sea will be fitted. This semaphore is about 160 feet above the level of the water line. The masts are to be provided with three derricks, two forward and one on the mainmast, and these derricks, primarily fitted for hoisting out the boats, will be of great utility when coaling. The boats include four steamboats, two 56 feet in length and two 40 feet in length, and fourteen sailing and pulling boats, ranging from a 42-foot sailing launch to a small dinghy. The two larger are capable of steaming about 13.5 knots, and are fitted with torpedo-dropping apparatus. They will also act as

scouts whilst the parent ship is in harbor. Three independent sets of dynamos and engines are required to light the ship, work the electric-motor fans and the searchlights. Every compartment except the double bottom, etc., will be efficiently lighted by incandescent lamps.

Bulwark.—The new battleship *Bulwark*, launched at Devonport on the 18th inst., was laid down on March 20, and has thus been under construction less than seven months. During that time 5,450 tons of material have been built into her, and it is claimed by the Devonport Dockyard staff that the work has created records both in the time she has been under construction and in the weight attained for the period. One of the three ships known as the *Venerable* class, the *Bulwark*, was designed by Sir W. H. White, Assistant Controller of the Navy and Director of Navy Construction, and she has been built under the supervision of Rear Admirals H. J. Carr and T. S. Jackson, Admiral Superintendents, and Mr. H. R. Champness, the Chief Constructor at Devonport Dockyard. The main dimensions of the ship are: Length between perpendiculars, 400 feet; extreme breadth, 75 feet; draught of water, forward, 26 feet 3 inches, aft, 27 feet 3 inches; load displacement, 15,000 tons. She will be fitted with two complete sets of engines of the vertical triple-expansion type of 15,000 indicated horsepower, and is expected to attain a speed of 18 knots. The engines, which are being made by Messrs. Hawthorn, Leslie & Co., of Newcastle-on-Tyne, have cylinders 31½ inches, 51½ inches and 84½ inches in diameter, and a stroke of 51 inches. Each set, in a separate room, is to be capable of developing 7,500 horsepower, with 108 revolutions per minute. There will be twenty boilers of the Belleville type. The armament will comprise four 12-inch breech-loading guns, worked in two barbettes, twelve 6-inch quick-firing guns in casemates; sixteen 12-pounder, 12-cwt. quick-firing guns; six 3-pounder Hotchkiss quick-firing guns; one 12-pounder, 8-cwt. boat gun, one 12-pounder, 8 cwt. field gun, and eight .45-inch Maxim guns. She will also have four submerged torpedo tubes. When commissioned the vessel will have a total of 773 officers and men. The *Bulwark* and her sister ships are identical in form, dimen-

sions and displacement with the *Formidable* class, but differ slightly in the distribution of armor protection. In the *Venerable* class the belt of side armor is carried much nearer the bow than in the *Formidable* class, while the fore armored bulkhead, which is a feature in the *Formidable* class, has been dispensed with. Despite its suggestiveness, few ships in the history of the Navy have borne the name *Bulwark*. It was not until 1861 that any ship of this name was built, this being a steam frigate launched at Chatham. The vessel now known as the *Impregnable*, training ship for boys at Devonport, bore the name for a short period. She was originally known as the *Howe*, but on the present battleship of that name being built, her name was changed to *Bulwark*, to be again changed to *Impregnable* when she was appropriated for her present service as a training ship.

Canopus.—The trials of the new first-class battleship *Canopus* have been successfully completed at Portsmouth. Her first run at one-fifth of her power was unsatisfactory, owing to the heavy consumption of coal caused by the waste of water due to leaky joints. She has now completed two more trials at one-fifth and four-fifths her power successfully, each run having been for thirty hours. The ship was on an even keel, the draught being 26 feet fore and aft; the steam in the boilers at the one-fifth-power run was 230 pounds to the square inch, and at the four-fifths trial 255 pounds; the vacuum at the one-fifth-power run was 27.2 inches starboard and 27 inches port, and during the four-fifths-power trial 26.5 inches starboard and 26.2 inches port; while the revolutions were 64.5 starboard and 63.9 port, and 100.1 starboard 99.3 port on the two runs respectively. During the one-fifth-power trial the engines developed 2,812-I.H.P., with a coal consumption for all purposes of 1.28 pounds per unit of H.P. per hour, and during the four-fifths-power run 10,454 I.H.P., with a coal consumption of 1.68 pounds for all purposes per H.P. per hour. The speed at the economical trial was not taken, but at the four-fifths-power run the patent log recorded a mean speed of 17.2 knots. At the eight hours' full-speed trial, the ship was on an even keel, drawing 26 feet; the pressure of steam in the boilers was 289 pounds; and the vacuum 25 inches star-

board, and 25.9 inches port. The engines worked with such evenness that as the mean of the eight hours' run they each showed 108.5 revolutions a minute, with a collective I.H.P. of 13,763, being 263 H.P. over the contract. The mean air pressure was .19 inch, and the mean speed was 18.5 knots, with a coal consumption of 1.72 pounds per H.P. per hour.

Cheerful (T. B. D.).—The trials of the new torpedo-boat destroyer *Cheerful* have been accepted as satisfactory. At the coal-consumption trial the engines indicated 5,632 H.P. with a speed of 29.941 knots. The consumption of coal was 2.84 pounds per I.H.P. per hour.

H. M. S. Venerable was launched on Thursday, November 2, from the Chatham Dockyard. She is a first-class barbette battleship, exactly similar to the *London* and *Bulwark*, launched recently from Portsmouth and Devonport respectively. The particulars officially supplied are as follows:

Length between perpendiculars, 400 feet; breadth, extreme, 75 feet; draught of water, forward, 26 feet 3 inches; draught of water, aft, 27 feet 3 inches; displacement, 15,000 tons; engines, inverted, vertical, triple-expansion; boilers, twenty of the Belleville type; indicated horse-power of engines, 15,000; speed, 18 knots; maker of engines, Maudslay Son and Field; coal stowage, 2,040 tons; complement (exclusive of admiral and his staff), 773.

Armament: Four 12-inch breech-loader wire guns; twelve 6-inch quick-firers; sixteen 12-pounder, 12 cwt. quick-firers; two 12-pounder, 8 cwt. quick-firers; six 3-pounder Hotchkiss; eight .45-inch Maxims; torpedo tubes (submerged), four; torpedoes, fourteen 18-inch and five 14-inch. Armor: Gun shields, 10-inch and 8-inch; on sides, 9-inch, 7-inch, 5-inch and 3-inch; bulkheads aft, 12 inches, 10 inches, and 9 inches; casemates, 6 inches; barbettes, 12 inches, 8 inches and 6 inches; conning towers, 14 inches, 12 inches and 3 inches; communication tubes, 3 inches and 8 inches; protective plating on bows, 2-inch. Protective deck plating—main deck, from armor board to station 20*a*, two thickness of 1 inch; from station 20*a* to stem, two thicknesses of ¾-inch; middle deck, from armor board to 28½ station level, two thicknesses of ½-inch; slope at sides, between 60 and

130, two thicknesses of 1-inch; before 60 and abaft 130, two thicknesses of ½-inch; lower deck, forward, two ½-inch thicknesses; abaft armor board, one 1-inch and one 1½-inch thickness.

The first keelplate was laid January 2, 1899; weight of hull when launched, 5,200 tons.

The Barham, cruiser, completed at Portsmouth, on the 25th ult., a series of progressive trials which were ordered to be carried out in order to compare results with later third-class cruisers, like the *Pelorus* and *Pandora*. The trials were begun on August 10 and 11, when the ship was run at her load draught of 11 feet 9 inches forward and 14 feet 9 inches aft, and they were continued on the 23d and 24th ult., at her light draught of 10 feet 6 inches forward and 14 feet 6 inches aft. In each case the result is the mean of four runs over the measured mile in Stokes Bay:

	Light Draught.	Load Draught.
Revolutions per minute,	100.1	101.2
Steam in boilers, pounds,	132	130
Indicated horsepower,	551	616
Speed in knots,	10.138	10.078
Revolutions per minute,	143.5	143.9
Steam in boilers, pounds,	138	127
Indicated horsepower,	1,701	1,899
Speed in knots,	14.266	14.164
Revolutions per minute,	177	183.5
Steam in boilers, pounds,	138	129
Indicated horsepower,	3,242	3,683
Speed in knots,	17.553	17.837
Revolutions per minute,	201.2	204.4
Steam in boilers, pounds,	138	138
Indicated horsepower,	5,008	5,410
Speed in knots,	19.512	19.585
Revolutions per minute,	210.4	202.2
Steam in boilers, pounds,	142	128
Indicated horsepower,	5,870	5,280
Speed in knots,	20.069	19.491

The vessel is at once to be brought forward for commission on the Mediterranean station.—"Engineering."

Prometheus.—The new third-class cruiser *Prometheus* has completed her four-hours' forced-draft trial successfully, with the following results: Pressure of steam in boilers, 262.6 pounds; ditto in engine room, 249.7 pounds; air pressure, 2.58 inches; vacuum, starboard, 24 inches, port, 24.1 inches; revolutions, starboard, 225.1, port, 219.9; I.H.P., starboard, high, 1,028.0, intermediate, 1.388.1, low, 1,238.7—total, 3,654.8; port, high, 1,036.9, intermediate, 1,309.3, low, 1,276.7—total, 3,619.9; aggregate I.H.P., 7,274.7; speed, 20.8 knots. The I.H.P. was 274.7 in excess of the contract with Earle's Shipbuilding and Engineering Company.

Perseus.—The new third-class cruiser *Perseus*, built and engined by Earle's Company at Hull, has completed her four-hours' forced-draft trial successfully, with the following results: Draught of water, forward, 11 feet 6 inches, aft, 14 feet 10 inches; pressure of steam, in boilers, 265.9 pounds, in engine room, 249.9 pounds; air pressure, 2.39 inches; vacuum, starboard, 24.2 inches, port, 23.3 inches; revolutions, starboard, 214.8, port, 214.6; mean pressure, starboard, high, 102.6, intermediate, 50.4, low, 18.9; port, high, 103.3, intermediate, 51.6, low, 18.7; I.H.P., starboard, 3,523.2, port, 3,545.5—total starboard and port, 7,068.7; speed, 20 knots. The contract with Earle's Company was for 7,000 H.P.

Coquette.—The new torpedo-boat destroyer *Coquette*, built by Thornycroft & Co., has also been successful, the result being as follows: Draught of water, forward, 5 feet 11½ inches, aft, 7 feet 4½ inches; speed, 30.211 knots; steam pressure in boilers, 216 pounds per square inch; air pressure in stokehold, 2.72 inches; vacuum in condensers, starboard, 25.0, port, 24.9; revolutions per minute, starboard, 383.8, port, 388.6; mean I.H.P., starboard, 2,820, port, 3,048—total, 5,868. The contract requirements were exceeded.

Espiegle and **Fantôme.**—These two new sloops are about to be laid down at Sheerness dock yard. Length, 185 feet; displacement, 1,040 tons. They will be improved *Condor* type, and will be steel, sheathed with wood. Triple-expansion engines and water-tube boilers will be used, and the armament will be six 4-inch rapid-fire rifles, four 3-pounders, and three machine guns.

Sheldrake Trials.—The nine 1,000-mile trials of this torpedo gunboat have been completed, and the results have been very satisfactory in regard to the performance of the Babcock & Wilcox boilers. The principal data of these trials are as follows:

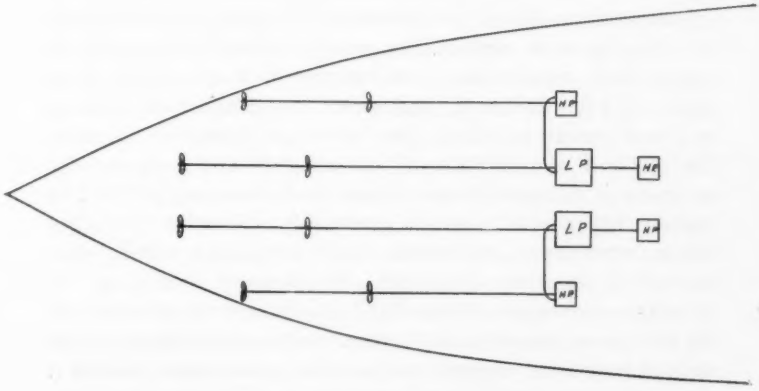
Date.	Nature of trial.	Duration in hours.	Steam pressure.	I.H.P.	Air pressure.	Coal per I.H.P. all purposes.	Coal per square foot of grate.	Water per pound of coal.	Ashes per pound of coal.	Grate surface.
1899.	*Miles. I.H.P.*									
28 February..	1,000 at 1,500	69	120	1,303	.0	1.61	12.3	...	.152	189
9 March	1,000 at 1,500	68	120	1,506	.0	1.6	12.67	...	.150	189
28 March	1,000 at 1,500	70	135	1,534	.0	1.75	14.2	...	.200	189
20 April	1,000 at 1,500	68½	130	1,537	.0	1.59	15.1	...	.150	189
5 May	1,000 at 1,800	67	135	1,829	.0	1.6	15.4	...	.216	189
19 May	1,000 at 1,800	66½	140	1,838	.0	1.68	16.4	...	.220	189
15 June.....	1,000 at 2,000	59	145	2,033	.0	1.57	17 0	...	.220	189
3 July.....	1,000 at 2,000	61½	140	2,042	.0	1.56	16.8	...	.230	189
20 July.....	1,000 at 2,150	56¾	150	2,245	.0	1.63	19.4	...	.250	189
Total.....		632¾	...	...	...	...	...	...	...	...
Mean.....		...	146	1,974	...	1.63	9.85	...	.198	...

The engines of the *Sheldrake* are triple-expansion type (twin screw), and are 22 by 33 by 49 inches with 21 inches stroke.

There are four B. & W. boilers, two boilers being in the forward compartment and two in the after compartment. Each pair of boilers is placed back to back, each boiler having its own stokehold. The total heating surface of each boiler is 2,356 square feet, and the grate surface 63 square feet. The boilers are worked at 200 pounds per square inch, which is reduced by reducing valves to 150 pounds per square inch at the engines, and the steam on its way to the engines passes through separators.

Viper and Class.—These turbine-engined torpedo-boat destroyers, now being built in England, with machinery similar to the little *Turbinia*, of Mr. C. A. Parsons, are described in Brassey's "Naval Annual." The length between perpendiculars is 210 feet, extreme beam, 21 feet, and the molded depth is 12 feet 9 inches. With a draught of 5 feet 4 inches, the displacement is 320 tons. There are four propeller shafts, each fitted with two screws and operated by two separate sets of engines. On each

side of the vessel is a high-pressure turbine motor, driving the outer screw shaft; and on each inner screw shaft is one low-pressure motor and one small reversing turbine motor, the inner screws being used for going astern. The total power is 10,000 I.H.P., which, it is calculated, will give a speed of 35 knots, with 16 knots going astern. On each side is a surface condenser, with two air pumps driven by turbines; but the two circulating pumps are operated by ordinary double-acting engines. The boiler-room weights, with water in boilers, is 100 tons 15 cwt.; engine-



room, with auxiliary gear and water in condensers, 52 tons 6 cwt.; propellers, shafting, etc., 7 tons 14 cwt. Consequently, with 12,000 H.P. developed, the weight of machinery is about 30 pounds per I.H.P. In a 30-knot torpedo-boat destroyer of ordinary design and similar size, the corresponding machinery weights are 78 tons, 56 tons and 10 tons; or, with 6,000 H.P. developed, about 53$\frac{3}{4}$ pounds per I.H.P. In the turbine engines the lowered center of gravity is also an advantage, and the machinery can be driven to the highest speed without danger.

In this connection we note the rumored great speed obtained in the recent trial of the *Viper*, but reliable data is not yet at hand upon which to base judgment regarding the possibilities of the turbine engine.

Thistle.—The new first-class gunboat *Thistle*, built and engined by the London and Glasgow Shipbuilding Company, has completed her contract steam trials. The *Thistle* is a sister ship to the *Dwarf*, which has just completed for sea at Devonport, and the satisfactory results which the latter vessel attained on her steam trial have been eclipsed by those now attained by the *Thistle*, which has already proved herself to be a far more economical steamer than the *Dwarf*, which on her 30-hours' run under the same conditions recorded a coal consumption of 2.37 pounds.

The mean results of the 30-hours' trial were: Steam in boilers, 186 pounds, at engines, 175 pounds; vacuum, starboard, 26 inches, port, 26.5 inches; revolutions, starboard, 230.5, port, 229.5; I.H.P., starboard, 344, port, 352—total, 696. Speed, 11.5 knots; coal consumed per I.H.P. per hour, 2.13 pounds. The result of the eight-hours' natural-draft trial were equally satisfactory, and as follows: Steam in boilers, 215 pounds, at engines, 205 pounds; vacuum, starboard, 25.5 inches, port, 25.7 inches; revolutions, starboard, 254.5, port, 255; I.H.P., starboard, 475, port, 485—total, 960. Air pressure, .5-inch; speed, 13 knots; coal consumed per I.H.P. per hour, 2.15 pounds. On the four-hours' forced-draft trial the results were: Steam in boilers, 220 pounds, at engines, 200 pounds; revolutions, starboard, 280, port, 282; I.H.P., starboard, 680, port, 670—total, 1,350. Air pressure, .75-inch; coal consumed per I.H.P. per hour, 2.47 pounds; speed, 13.5 knots.—"United Service."

FRANCE.

Suffren.—This first-class battleship, which was successfully launched at Brest on 25th of last July, is hoped to be completed by July, 1901. If these dates are observed, the period of her construction will be thirty-one months, which will be less than any other French battleship hitherto built. She is also the largest battleship built by the French up to the present, her tonnage displacement being 12,728. The other dimensions are: Length, 125.5 meters (411 feet); beam, 21.36 meters (69 feet); draught, 8.4 meters (27½ feet). She will have three propellers

driven by vertical triple-expansion engines, and water-tube boilers of a collective H.P. of 16,200, giving an estimated full speed of 18 knots. The normal coal supply will be 820 tons, which can be increased to 1,150 tons. With normal stowage her radius of action will be 5,100 at 10 knots, and 1,100 miles at full speed, and with the extra coal these distances are increased to 7,000 and 1,800 miles respectively. The hull at the water line is protected from end to end by a Harveyized steel belt with a maximum thickness of 300 millimeters (11.8 inches), extending to a height of 1.10 meters (3.6 feet) above the water line. Armor to a height of 2 meters (6.5 feet), 130 millimeters (5.1 inches) thick protects the battery for the Q.F. guns on the upper deck, which, as in the *Charlemagne* and her sisters, has the defect of leaving a considerable extent of side between the lower belt and the upper deck exposed without protection to shell fire. There is also an armored deck 70 millimeters (2.7 inches) thick at the top of the belt. The armament is entirely protected by armor, and consists of: Four 305-millimeter (12-inch) guns in pairs in the two turrets forward and aft in the midship line; ten 164-millimeter (6.4-inch) Q.F. guns, four of which are mounted in the battery and six in turrets above the battery; eight 100-millimeter (3.9-inch) guns; twenty 47-millimeter (1.8-inch) guns; two 37-millimeter (1.4-inch) guns; and four torpedo tubes, two of which are submerged. The plans of the *Suffren* are by M. Thibaudier, and her cost will be 29,492,887 francs (£1,179,715 10s.).

Infernet.—This third-class cruiser was launched from the Chantiers de la Gironde at Bordeaux on September 7. Her dimensions are as follows:

Length, 311 feet; beam, 39 feet; displacement, 2,460 tons, with a mean draught of 15 feet 6 inches. Unlike the larger number of French cruisers the, *Infernet* has nearly a straight stem, while her stern above water comes to a sharp point. There will be four groups of water-tube boilers on the Normand system, which have been constructed at the Creusot works; the boilers, eight in number, containing 8,112 tubes, will be in four stokeholds. The engines, of the usual triple-expansion type, with four cylinders, are to develop 8,500 I.H.P. under forced draft,

which, with 175 revolutions, are to give a speed of 21 knots. The engines will be placed in separate compartments, divided by a watertight bulkhead. The armament will consist of two 140-millimeter (5.4-inch) Q.F. guns, four 100-millimeter (3.9-inch) Q.F. guns, with eight 3-pounders; the 3.9-inch guns being in sponsons on the broadside, and the 3-pounders, six on the spar-deck and two under the poop. The ship also carries fourteen automatic torpedoes, fitted with a special releasing attachment, permitting of their being discharged with great rapidity. As is their custom with small vessels, the builders have launched the ship with engines and boilers in place, so that the ship is almost in condition to make her preliminary trials, after which she will proceed to Rochefort for her official ones. She was commissioned on December 9, 1896. There are at present under construction at the same yard the first-class armored cruiser *Kléber* and torpedo boats *Nos. 239*, *240* and *241*.

Admiral Gueydon.—On Wednesday, September 20, this new first-class armored cruiser was launched from the Government yard at Lorient. Her dimensions are as follows: Length, 452 feet 9 inches; beam, 63 feet 8 inches; displacement, 9,517 tons, with a draught of 24 feet 7 inches. She will have three screws, and her engines are to develop 20,000 I.H.P., giving a speed of 21 knots under forced draft. The normal stowage is 1,020 tons, but she can carry 1,600 tons. In the first case, she has a radius of action of 1,230 miles at full speed, and 6,500 miles at 10 knots. With her full coal stowage, her radius of action is 1,920 miles at full, and 10,300 at 10 knots speed. Her boilers will be of the Niclausse water-tube type. She will have a water-line belt of 6.8 inches hardened steel, tapering at the extremities to 3.5 inches, with a belt above, 3.5 inches thick, reaching to the main deck, while guns will be protected by 8-inch armor on the turrets for the two heavy ones, and 3.8-inch armor on the casemates for the secondary battery. The armament will consist of two 19.4-centimeter (7.6-inch) guns in the turrets, one forward and one aft; eight 16.4-centimeter (6.4-inch) Q.F. guns in casemates; four 10-centimeter (3.9-inch) Q.F., and sixteen 3 and 1-pounder Q.F. guns, with two submerged torpedo tubes. The ship is to be

completed by the end of 1901, the order of her construction having been given on the 13th of August, 1897.—"Le Temps" and "Le Yacht."

Battleship Alterations.—Recently French battleships have undergone extensive alterations to lighten them by reducing the weight of the armor and of the artillery, and by abolishing part of the superstructure, removing in some cases, for instance, one of the two military masts. In reducing the weight of the artillery modern quick-firing guns have been substituted, and in altering the superstructure wood has been as much as possible dispensed with. The transformation has included the substitution of water-tube boilers for the existing ones, and in some ships a change of the engines. The *Redoubtable* has now triple-expansion engines, her 27.44-centimeter guns have been replaced by others of 24 centimeters, and the 13.86 centimeters by 10 centimeters. In the course of a few years she will be fitted with water-tube boilers. The *Devastation* has her new guns already, and will receive her new boilers in the course of a few months. The *Courbet* is about to change her guns at Brest. Her boilers are almost new, but in the course of a few years they will be replaced by water-tube boilers. The *Formidable* and the *Amiral Baudin* have already undergone a first change in their artillery by the substitution of four 16.47-centimeter guns placed in two casemates with 10-centimeter protection for one 37-centimeter gun amidships. The second change will consist of the 37-centimeter guns fore and aft being replaced by 27.44 centimeter guns of 40 caliber, in turrets. On the *Amiral Duperré* the 34-centimeter gun amidships will be exchanged for 16.47-centimeter guns placed as in the *Formidable* and *Baudin*. The four more recent vessels, the *Hoche*, *Neptune*, *Marceau* and *Magenta*, are undergoing, or will undergo, a reduction in their superstructure and a change in their boilers. The *Hoche* is receiving Belleville boilers, and Niclausse boilers will be placed in the *Marceau*. In addition to the battleships, the coast-defense ships *Requin*, *Indomptable* and *Furieux*, are to have their armor reduced and the 42-centimeter guns replaced by 27.44 centimeter. They are also to receive Niclausse boilers.

GERMANY.

Cruiser A.—The first-class cruiser *A* will be of 394 feet in length, 44 feet 6 inches beam, 24 feet draught and 8,868 tons displacement. Her armor will consist of a belt 3.94 inches, a protective deck of from 1.97 inches to 2.75 inches, and of turrets 4 inches to 6 inches thickness. Three triple-expansion engines, of 15,000 I.H.P., will receive steam from Dürr boilers, and will give the vessel a speed of 20.5 knots. The normal coal capacity will be 950 tons. The armament, entirely composed of quick-firing guns, will consist of two 40-caliber long, 24-centimeter, in two turrets 6 inches thick; ten 15-centimeter, equally long, of which four are in 4-inch turrets and 6-inch armored casemates of equal strength; ten of 8.8-centimeter, of 30-calibers, and ten of 3.7-centimeter guns on the upper deck and the superstructures. Four 8-millimeter machine guns and four 45-centimeter torpedo tubes, of which one will be forward and two aft, in the broadside below the water line, and one aft, above the water line, will complete the armament. The cruiser will have a crew of 523 men.

Steam Trials.—The new second-class cruiser *Victoria-Louise* has completed her trials successfully, having averaged 19.1 on her run under forced draft, the stipulated contract speed for her and her sister ships being 19 knots.

Cruiser Tiger, formerly *Ersatz Wolf*, belonging to the *Iltis* class, has been launched recently in Danzig. The new gunboat has a displacement of 894 tons, engines of 1,300 I.H.P., and a speed of 13.5 knots. Coal supply will suffice for 3,000 sea miles at 10-knot speed. Armament consists of four 8.8 centimeter rapid-firing guns, six 3.7 centimeter machine guns and two machine rifles.

Cruisers Vineta and **Freya** are ready for their trials. These ships are of special interest, because of their equipment with water-tube boilers of different systems. *Freya* has Niclausse boilers, *Vineta*, as well as the *Victoria-Louise*, have Dürr boilers, and the two sister ships, *Hertha* and *Hansa*, have Belleville boilers. *Vineta* and *Hansa* have a displacement each of 5,900 tons, *Victoria-Louise*, *Hertha* and *Freya* each 5,630 tons.

ITALY.

Agordat.—The "Escercito Italiano" states that the Italian cruiser *Agordat* was successfully launched at Castellamare di Stabia on October 12. Her length is 87.60 meters; beam, 9.32 meters; draught, forward, 3.03, aft, 4.25 meters; displacement, 1,320 tons. She has two engines of triple-expansion type, developing 7,500 horsepower, and supplied with steam by eight water-tube boilers of the Blechynden type, with a pressure of 15 atmospheres. The interior of the *Agordat* is of soft steel, wood being used as little as possible, and in many cases aluminum is substituted. She has a deck of hardened steel extending along her whole length. Her armament consists of fourteen 7.6-centimeter quick-firing guns, two machine guns and two torpedo tubes. A short time ago the *Lampo*, torpedo-boat destroyer, built for the Italian government by Messrs. Schichau, of Elbing, was launched. Her length is 60 meters, and her nominal speed under forced draft 36 knots.

JAPAN.

Idzumo.—Sir W. G. Armstrong, Whitworth & Co. launched the Japanese first-class armored cruiser *Idzumo* on the 19th September. The principal dimensions of the vessel are as follow: Length between perpendiculars, 400 feet; breadth, 68 feet 6 inches; depth, 41 feet; draught, 24 feet 3 inches; displacement, 9,750 tons. The armament consists of four 8-inch breech-loading guns, twin mounted, in barbettes; fourteen 6-inch quick-firing guns—ten in casemates, six on the main deck and four on the upper deck, the remaining four being on the upper deck, protected by shields; seventeen 12-pounder quick-firing guns—eight on the shelter decks, two on the main decks forward, four on the bulwarks and three in the military tops; four submerged torpedo tubes—two forward and two aft. The vessel has a complete waterline belt of Harveyed nickel-steel armor 7 inches thick amidships, reduced at the ends. Above this there is a citadel of 5-inch Harveyed nickel-steel armor inclosing the bases of the barbettes, and carried from the top of the waterline belt to the main deck. The barbettes are of Harveyed nickel-steel 6 inches thick; the casemates are of nickel-steel 6 inches thick,

and the conning tower is Harveyed nickel-steel 14 inches thick. The machinery is of the twin-screw, vertical, triple-expansion type, to develop 14,500 indicated horsepower, and the speed guaranteed is 20¾ knots, the boilers being of the Belleville latest type. She has a bunker capacity for about 1,600 tons of coal. Accommodation is provided for an admiral, 52 officers and 430 petty officers and men. The vessel is a sister ship of the *Asama* and *Tokiwa*.

Shikishima.—On May 1, 1897, the first plate of the keel of this fine battleship was laid, and within twenty-nine months (notwithstanding a six-months' delay in the delivery of armor, armament and engines, due to the unfortunate engineers' strike) her trials have been completed to the entire satisfaction of all parties concerned. This probably constitutes a record in the history of battleship building, and the fact that a war vessel of some 15,000 tons displacement and 19 knots speed can be completely built, equipped, armored, armed and engined in a little over two years, speaks well for the methods and facilities of the Thames Iron Works, Shipbuilding and Engineering Company, the contractors for the vessel.

The ship having been dry-docked at Portsmouth, and her bottom having received her final coating of anti-fouling composition, on October 10 she left that port for Torbay, to run an 8-knot course in deep water. The engines worked smoothly during the whole of the time, indicating upwards of 15,000 horsepower on the measured distance, and she recorded a mean speed of 19.023 knots at slightly over her load draught of 27 feet 3 inches. She turned a complete circle in three minutes sixteen seconds, heeling only 5 degrees, her rudder being put from hard over to hard over in sixteen seconds.

The following are a few of her leading particulars:

Length over all, 438 feet; length between perpendiculars, 400 feet; breadth, extreme, 75 feet 6 inches; depth, extreme, 45 feet 2½ inches; draught, mean, 27 feet 3 inches; displacement at mean draught, 14,850 tons; indicated horsepower, (over) 15,000; number and type of boilers, 25 Belleville; heating surface, 40,000 square feet; mean speed on trial, 19.023 knots; number of screws,

two; side armor, Harveyized nickel-steel; maximum depth, 8 feet 2 inches; maximum thickness, 9 inches; minimum thickness, 4 inches; thickness of barbette armor, 14 inches; number of incandescent 16-candlepower lamps, 800; number of 24-inch searchlights, 6; power of 24-inch searchlights, 20,000 candlepower.

The armament of the *Shikishima* consists of four 12-inch 40-caliber guns, two in each barbette; fourteen 6-inch quick-firing guns, mounted in casemates; twenty 12-pounder guns; twelve 47-millimeter quick-firing guns; four 18-inch torpedo tubes, below water line, and one similar tube above water line.

In general constructive details the *Shikishima* follows the usual methods employed for ships of this class in the British Navy. She is built on the usual bracket-frame system, with wing passages on each side, to be used for holding coal. She has a double bottom amidships, with watertight flats at the ends of the vessel, thus having practically a double bottom from end to end. The armor is of Harveyized nickel-steel. The side protection consists of a belt which extends from stem to stern. The belt is 8 feet 2 inches in maximum depth. It is 9 inches thick amidships, and tapers to 4 inches thick at the ends. It has a vertical extension of 5 feet 6 inches below the water line, and 2 feet 8 inches above, at the designed load draught.

Above this belt, and carried to the height of the main deck, there is side armor 6 inches thick for a length of 250 feet, with screen bulkheads at ends also 6 inches thick, forming a complete armored citadel, extending longitudinally over the space between the two barbettes. Between the armor deck and the belt deck there are 12-inch screen bulkheads, which join the barbettes to the side armor. The armored deck is arranged according to the modern principle, as in the ships of the *Canopus* class, its sides being joined to the lower edges of the belt. It has sufficient curve to rise 2 feet 8 inches above the water line amidships. From stem to stern it is 2 inches thick, but an extra plate of 1½ inches thick is worked on the slope of this deck within the citadel, so that in this part the total thickness of the deck is 3½ inches.

Yakumo.—The principal dimensions of this first-class armored

cruiser, which was launched from the Vulcan Company's yard at Stettin, last July, are as follows: Length, 407 feet 9 inches; beam, 64 feet 4 inches; mean draught, 23 feet 9 inches, with a displacement of 9,850 tons. The boilers will be water-tube, of the Belleville type, and her engines are to develop 11,200 I.H.P. under natural draft, giving a speed of 18 knots, and 16,000 I.H.P. under forced draft, giving a speed of 20 knots. Her normal coal supply will be 600 tons, giving a radius of action of 5,000 miles at 10 knots, but 1,100 tons can be carried when necessary, which will give a radius of action of nearly 10,000 miles at economical speed. Protection will be afforded by a complete armor water-line belt of hardened steel, with a maximum thickness of 7 inches, tapering to 3.5 inches at the extremities, while the armor on the two turrets for the heavy guns and the casemates for the 6-inch Q.F. guns will be of 6-inch steel, also hardened by the Krupp process, and the armored deck, 2.5-inch steel. Her armament, which is to be supplied by the Elswick firm, will consist of four 8-inch Q.F. guns, two in each turret, one forward and one aft; six 6-inch Q.F. guns in casemates; twelve 12-pounder and seven 2.5-pounder Q.F. guns, with five torpedo-tubes, one above water in the stem and the other four submerged.

RUSSIA.

Pallada.—This new second-class cruiser, built at the Franco-Russian Works, on Galernii Island, St. Petersburg, was launched on the 20th September, in presence of the Tsar, Tsaritsa, and other distinguished personages.

Her dimensions are as follows: Length, 406 feet; beam, 55 feet; displacement, 6,630 tons, with a mean draught of 21 feet. The armament will consist of eight 45-caliber 6-inch Q. F. guns, twenty 3-inch 12-pounder Q.F. guns, and eight smaller Q.F. guns. It was originally intended to give this ship and her four sisters six 4.7-inch Q.F. guns, but the authorities seem to have decided in favor of a larger battery of 12-pounders. The engines are to develop 16,000 I.H.P., giving an estimated sea speed of 19 knots. There will be three screws, and steam will be provided by twenty-four Belleville water-tube boilers. There is an armored

deck 1.5 inches thick on the flat and 2.5 inches thick on the slopes, while coal bunkers are situated immediately above and below the slopes of the armored deck. Great care has been taken to avoid the use of wood, the bed places in the cabins even being of steel.

Variag.—The Russian cruiser *Variag*, constructed by the Messrs. Cramps, of Philadelphia, was successfully launched from the yards of the builders on October 31. The ceremony of the Russian Orthodox Church was performed as the vessel glided into the stream. As the ship moved down the ways, the Rev. Hotovitsky, gowned in yellow robes, read from the Greek Testament and recited a chant, in which the Russian officers and sailors joined. A large gilded cross was waved before the bow, and holy water sprinkled on it. The contract requires that the *Variag* make a speed of 23 knots an hour for twelve hours. No date has yet been set for the trial trip.

Borodino.—The "Kronstadtski Vicstnik" publishes some particulars of the Russian battleship *Borodino*, building at the docks of the New Admiralty, St. Petersburg. The length of the vessel is 397 feet; beam, 76 feet; draught on an even keel, 26 feet; displacement, 13,600 tons. Her engines will develop 16,000 horsepower. Like the *Tsarevitch*, building in France, she will have a special protection, $1\frac{9}{16}$ inches thick, against torpedoes. Her belt of armor will be 7 inches thick in the upper part, 9 inches in the middle, and 4 inches in the lower part.

SWEDEN.

The Swedish government are at present adding to their navy two 20-knot cruisers, the *Clas Uggla* and the *Psilander*. These are being built at the Bergsund Works, Stockholm, the machinery being constructed at Motala. Also the battleship *Dristigheten* is being constructed at Lindholm, Gothenburg. The Swedish Board of Admiralty have selected the Yarrow type of water-tube boiler for these vessels.

Dristigheten.—Towards the end of last year the first keel plate of the new coast-defence battleship *Dristigheten* was laid at the Lindholm yard at Gothenburg, for the Swedish Navy. She is slightly larger than her predecessors, the *Thor* and *Njord*,

which were both launched last year from the same yard. Her dimensions are as follows: Length, 285 feet 6 inches; beam, 49 feet 3 inches; displacement, 3,500 tons, with a mean draught of 16 feet. The engines are to develop 5,000 I.H.P., giving a speed of 16 knots; the boilers, which are of the Yarrow water-tube type, are being constructed at the Motala Engine Works. Protection is afforded by a complete water-line belt of nickel-steel 8 inches thick, but tapering to 4 inches at the extremities; the conning tower is similarly protected, while the armor on the turrets for the heavy guns is 8 inches in front, tapering to 6 inches in rear, while the casemates for the secondary battery are of 5-inch steel. All the armor is being made by the French firm of St. Chamond.

The armament will consist of two 21-centimeter (8.2-inch) guns, one forward and one aft in turrets, and six 15-centimeter (5.9-inch) Q.F. guns in a central battery amidships, with ten 5.7-centimeter (2.2-inch) and four 3.7-centimeter (1.4-inch) smaller Q.F. guns, and two submerged torpedo tubes for 18-inch torpedoes on the broadside. All the guns are being made at the Bofors Works.

MERCHANT STEAMERS.

Twenty-five New Steel Ships.—At prices now prevailing for vessel property on the Great Lakes the value of twenty-five steel vessels under contract with the American Shipbuilding Co. and three independent yards, is $7,637,000. An estimate made a short time ago referred only to vessels being built by the consolidated ship yards, and the total value was based on contract prices. These twenty-five vessels, with one exception, are freight carriers, and all are to come out in 1900. A couple of steamers to be completed this fall—one at Detroit and the other at Toledo—are not included. Neither does the list include wooden vessels, although James Davidson, of West Bay City, Mich., has one very large wooden vessel on the stocks, and will probably build two more to come out in 1900. Of the twenty-four steel freighters only four are tow barges. In a single trip this fleet will carry 150,200 gross tons, and in a full season just about 3,000,000 gross tons, but its capacity for 1900 will probably not reach much more than half the latter figure, on account of delays that will be encountered in the ship yard. Some of the vessels will not be out until very late next fall. The list follows:

BUILDING BY AMERICAN SHIPBUILDING CO. FOR:	Approximate value at present prices.	Estimated capacity, gross tons in one trip.
A. B. Wolvin and American Steel and Wire interests, four 500-foot steamers	$1,550,000	32,000
A. B. Wolvin and others, two Welland-Canal size steamers	345,000	6,000
Carnegie-Oliver steel interest, six steamers	2,280,000	44,500
Bessemer Steamship Co., one steamer and two tow barges	775,000	21,000
Eddy Bros. of West Bay City, two steamers	680,000	12,100
John Mitchell of Cleveland, one steamer	350,000	6,100
Minnesota Steamship Co., two tow barges	450,000	14,400
Robert R. Rhodes, Cleveland, one Welland-Canal size steamer	172,000	3,000
Detroit and St. Clair River Excursion Company, a passenger steamer	300,000	.....

	Approximate value at present prices.	Estimated capacity, gross tons in one trip.
BUILDING BY UNION DRY DOCK CO. OF BUFFALO FOR:		
Lehigh Valley Trans. Co., one package freighter.....	395,000	5,100
BUILDING BY CRAIG SHIPBUILDING CO. OF TOLEDO FOR:		
Arthur Hawgood and others of Cleveland, one Welland-Canal size steamer	170,000	3,000
BUILDING BY JENKS SHIPBUILDING CO. OF PORT HURON FOR:		
Account of sale, one Welland-Canal size steamer.....	170,000	3,000
	$7,637,000	150,200

Oceanic.—We are able to add here to the machinery data published in May number of the JOURNAL (page 262), of this latest of the large steamers of the Oceanic Steam Navigation Company, repeating some items in order to assemble the principal dimensions.

Engines.—Four-cylinder, triple-expansion, inverted, vertical type, with cylinder diameters of high pressure, 47.5 inches; intermediate pressure, 79 inches; low pressure (2), 93 inches, with a common stroke of 72 inches. Piston valves are used on the high and intermediate cylinders, and double-ported slide valves on the low pressure. Indicated horsepower is 28,000.

The ship has twin screws, and the propellers being made of Manganese bronze, and are 22 feet 3 inches in diameter.

The condensers are of the independent, cylindrical type, but the air pump is driven from the low-pressure crossheads of main engines.

The shafting is hollow, and crank shaft is 25 inches diameter, with crank pins 26 inches diameter.

Boilers.—There are fifteen double-ended, cylindrical, Scotch boilers, as follows:

Three of 16 feet 6 inches diameter; ten of 15 feet 3 inches diameter; two of 14 feet 10 inches diameter, each being 18 feet 6 inches long.

The first named three have four furnaces at each end, while the remaining twelve have but three furnaces at each end, making a total of ninety-six furnaces. The length of the grate is 5 feet

9 inches in all furnaces, while the width varies but slightly, being 3 feet 4 inches in the three largest boilers, 3 feet 7 inches in the ten intermediate boilers, and 3 feet 6 inches in the two smallest boilers, the largest boilers having less width of grate, owing to having four furnaces at each end.

Aggregate grate surface is 1,937.75 square feet, while the total heating surface is 73,966 square feet.

A steam pressure of 192 pounds per square inch is carried, but the boilers have been tested to 400 pounds per square inch.

The average daily consumption of coal is about 400 tons, per day, but accurate log data of engine speed and ship speed are not yet available.

Ivernia.—The successful launching of the Cunard Line steamship *Ivernia* from beneath one of the large sheds of the shipbuilders, Messrs. C. S. Swan and Hunter, Limited, Wallsend-on-Tyne, on September 21, was a "red letter" event for the North-East Coast, and was witnessed by many of the leading shipbuilding experts of the district. With one exception, that of the White Star Liner *Oceanic*, the *Ivernia* is the largest vessel at present afloat that has been built in the United Kingdom, the *Great Eastern* necessarily being excepted. There are other two larger vessels built in Germany, and it will be interesting to contrast the gross register tonnage of these four largest vessels afloat.

The *Oceanic* is 17,274 tons.

The *Deutschland* is 15,500 tons.

The *Kaiser-Wilhelm der Grosse* is 14,349 tons.

The *Ivernia* is about 13,900 tons.

The keel was laid on December 6th of last year, and considering the difficulty they have had to contend with owing to the scarcity of men and the short time that the men obtainable are working, the work has been done very expeditiously. It is expected that the *Ivernia* will take up her station on the Liverpool and Boston service early next year.

The *Ivernia* is intended for the company's line between Liverpool and Boston, and is designed mainly for the carriage of cargo, third-class passengers and cattle, although a few first and sec-

ond-class passengers will be carried, about 150 of the former and about 200 of the latter. Of third-class passengers she will carry about 1,000; 500 of these are accommodated in two, four and six-berthed state rooms. Stalls will be fitted for about 800 head of cattle and 80 horses.

The leading particulars of the vessel are: Length over all, 600 feet; length between perpendiculars, 580 feet; beam, extreme, 64 feet 6 inches; depth molded to upper deck, 41 feet 6 inches; depth molded to shelter deck, 49 feet 6 inches; gross tonnage, about 13,900 tons; speed on trial, 16¼ knots. There are four complete steel decks—lower, main, upper and shelter; and a steel orlop deck from the boiler-room forward to the stem, and a bridge deck 280 feet long above the shelter deck. The space between the orlop and lower decks forward is insulated for carrying chilled beef, three large refrigerating engines being fitted in a house on the upper deck, and also a smaller one for the ship's own stores.

The engines are of the quadruple-expansion type, the diameters of the cylinders being 28½, 41, 58½ and 84 inches respectively for the high, first intermediate, second intermediate and low pressure, with a stroke of 54 inches. The arrangement of cylinders from the forward end is somewhat unusual—high pressure, low pressure, first intermediate, second intermediate. Each cylinder, which has two bodies, and also double covers, is carried on two cast-iron columns of box form with separate faces, and the usual pumps are worked from the crossheads, the condenser being behind. The soleplate is of cast iron, and, like the columns, very massive. This is the more interesting as the Wallsend Company make all their own castings. All the shafting is of steel, forged by hydraulic pressure when the metal is in the fluid condition, as carried out at Whitworth's works. The propellers are three-bladed and of Manganese bronze, with cast-iron bosses. There are nine boilers, all single-ended. They are to work at 210 pounds pressure. They will all go into one boiler room, six being placed back to back in double rows across the ship, with three boilers at the after end, so that there will be three rows and two stoking platforms, from one of which six boilers will be fired, and from the other only three will be fired. There is a separate

donkey boiler. There will only be one funnel, but it will be 140 feet high from the keel, and it is 15 feet in diameter. The steam pipes are of wrought iron, lap welded, with expansion joints. They and much of the auxiliary machinery came from Glasgow.

Islanda.—Messrs. Sir Raylton Dixon & Co. (Ltd.) launched on October 7th the steamer *Islanda*, built to the order of Messrs. British India Steam Navigation Company, of London, for their Eastern trade. The principal dimensions are: Length, 424 feet 6 inches; breadth, 50 feet 8½ inches; depth, 32 feet, and the deadweight carrying capacity about 8,000 tons. The principal decks are of steel and iron, the upper deck being sheathed with teak. The water ballast will be carried in a cellular double bottom all fore and aft, also in fore and aft peaks, and large deep tanks in No. 3 hold. Triple-expansion engines will be fitted by Messrs. T. Richardson & Sons (Ltd.), Hartlepool, having cylinders 26½ inches, 42 inches, 66½ inches, by 51 inches stroke, supplied with steam by large single-ended boilers working at 160 pounds pressure, fitted with Howden's system of forced draft.

Trent.—Messrs. Robert Napier & Sons, Limited, Govan, launched on the 19th September, the *Trent*, the second of two steel screw steamers which they have on hand for the Royal Mail Steam Packet Company, London. The general dimensions are: Length, 425 feet; breadth, 50 feet; depth, 35 feet; gross tonnage, about 5,500. Accommodation has been provided for a large number of first-class passengers. The machinery consists of a set of triple-expansion engines of 7,000 indicated horsepower, with six single-ended steel boilers for a working pressure of 180 pounds, with Howden's system of forced draft.—"Engineering."

Granada.—Messrs. John Priestman & Co., Southwick, launched on September 9th the screw steamer *Granada*, built to the order of Messrs. A. C. de Feritas & Co., of Hamburg, for the Argentine and Canadian cattle trade. The principal dimensions are: Length, 410 feet; breadth, extreme, 52 feet 2 inches; depth molded to shelter deck, 38 feet 7 inches; having a total displacement of about 11,000 tons. The engines and boilers

will be supplied by Messrs. T. Richardson & Sons, Limited, West Hartlepool. The cylinders are 27 inches, 43 inches and 72 inches in diameter, with a stroke of 48 inches. Steam will be supplied by three boilers at a working pressure of 180 pounds per square inch.—"Engineers' Gazette."

La Lorraine.—This, the first of the new French Transatlantic steamers, has been launched, and is now being hurried towards completion. The length is 580 feet 8 inches; beam, 60 feet 2½ inches; molded depth, 39 feet 4 inches; draught, 25 feet 3 inches; and displacement, 15,200 tons. She will have five decks, with a bridge deck 340 feet long, and poop and forecastle. Like all modern steamers, she will have special cabins *de luxe* for 59 passengers. Then the ordinary first-class passengers number 378, the second-class 118 and the third-class 953, with a crew of 372. The vessel will have sixteen watertight compartments, and the double bottom will have capacity for 1,100 tons. There will be sixteen boilers of the cylindrical type, each 17 feet in diameter and 10 feet 10 inches long, with four furnaces of 3 feet 8 inches diameter, making 64 furnaces in all. The boilers will be placed in four stokeholds, and there will be bunkers for 3,000 tons of fuel. The working steam pressure will be only 165 pounds per square inch. The engines are of the triple-expansion type, with four cylinders, twin screws, of course, being adopted. The machinery space, including bunkers, occupies 58 per cent. of the length of the ship. The power is expected to work out to 22,000 indicated horsepower for the 22-knot speed. The vessel will be used as an armored cruiser, and mountings are provided for nine 5½-inch quick-firing guns and eight 1.47-inch quick-firers.—"Engineering."

ASSOCIATION NOTES.

At the regular October meeting of this Society the following officers were placed in nomination for 1900:

For President, Commander Harrie Webster; Lieutenant Commander F. H. Bailey.

For Secretary-Treasurer, Lieutenant Commander A. B. Willits; Lieutenant W. W. White.

For Council (three to be chosen), Lieutenant Commander F. H. Bailey, U. S. N.; Lieutenant Commander W. F. Worthington, U. S. N.; Lieutenant R. S. Griffin, U. S. N.; Lieutenant B. C. Bryan, U. S. N.; Lieutenant C. A. E. King, U. S. N.; Lieutenant W. W. White, U. S. N.

Separate voting slips will be mailed to each member, with return envelopes, and it is requested that each voter give prompt attention to the matter in order that a full vote may be recorded.

A second voting slip will be mailed at the same time as the above, for the purpose of fixing upon the articles for prize awards printed in the current volume. In this connection it appears to be true that the offer of prizes does not draw out the efforts intended or hoped for. There are two suggested reasons for this; one being that of the widely scattered membership, due to the service demands. This prevents those well attended meetings, which would conduce to reviving direct interest in such matters. The second reason is that the producers of professional manuscripts in the Society find greater satisfaction in marketing their productions than in devoting their labors to enhancing the value of the JOURNAL, even with a hope of the award of a life membership together with a medal and a "purse."

At the next regular meeting, in January, a proposition will be made to again change the article governing this feature so as to do away with the prize essays altogether, and simply permit the purchase of such manuscripts, as the council may find valuable and desirable, at a fair current rate.

We have been requested to give notice of an International Congress of Naval Architects, which will be held under the patronage of the French Government, in the Palais des Congress, of the Exposition of 1900, and opening on the 19th of July, for three days' continuance.

This congress is of interest to engineers and constructors of ships, and of motor and mechanical apparatus of every kind employed in ships, to the manufacturers of material and objects of whatever kind that may be used either in naval construction or in yards and workshops, to sailors, ship owners and yachtmen, and to everyone who is in any way concerned in the progress of maritime locomotion. All such persons are earnestly invited to help the congress with the fruit of their experience, investigations and studies. They can do this by presenting communications to be read and discussed during the sessions, by taking part in the discussions, or as listeners. The printed report of the communications and discussions will be presented to each of the active members of the congress.

Correspondence is solicited from those who contemplate aiding with papers on any branch of the subjects to be discussed, viz:

A. Naval architecture, geometry, and status of ship stability and geneneral theories.

B. Hull construction.

C. Machinery construction.

D. Special types of vessels for particular service.

E. Heavy outfitting of dock yards, etc.

F. Miscellaneous, history and development of merchant, pleasure and war vessels, etc., and including any relevant matter to marine progress or education in Marine engineering.

The Secretary-General is Mr. Hauser, Ingenieur de la Marinè en retraite, 4 Rue Meissonnier, Paris, to whom further inquiries may be addressed.

A membership fee of 15 francs is fixed, and this will entitle the holder of a membership to a copy of the report of the proceedings

Persons desiring to present papers should send same before June 1, 1900, accompanied with a "brief" and summing up of conclusions.

OFFICERS AND MEMBERS

AMERICAN SOCIETY OF NAVAL ENGINEERS.

1899.

AMERICAN SOCIETY OF NAVAL ENGINEERS.

OFFICERS FOR 1899.

President:

Chief Engineer **H. Webster**, U. S. Navy.

Secretary and Treasurer:

Chief Engineer **A. B. Willits**, U. S. Navy.

Council:

Chief Engineer **H. Webster**, U. S. Navy.
Chief Engineer **A. B. Willits**, U. S. Navy.
Passed Assistant Engineer **C. A. E. King**, U. S. Navy.
Passed Assistant Engineer **W. W. White**, U. S. Navy.
Passed Assistant Engineer **Emil Theiss**, U. S. Navy.

HONORARY MEMBERS.

(EX-OFFICIO.)

The Secretary of the Navy.

The Assistant Secretary of the Navy.

Chief of Bureau of Steam Engineering:

Geo. W. Melville, Engineer-in-Chief, U. S. N., Navy Department.

Ex-Chiefs of Bureau of Steam Engineering:

Chas. H. Haswell, Consulting and Superintending Engineer, 42 Broadway, New York.
B. F. Isherwood, Chief Engineer, U. S. N. (retired), 111 East 36th street, New York.
J. W. King, Chief Engineer, U. S. N. (retired), 3231 Powellton avenue, Philadelphia.
Chas. H. Loring, Chief Engineer, U. S. N. (retired), 239 Clermont avenue, Brooklyn.
Wm. H. Shock, Chief Engineer, U. S. N. (retired), 1404 15th street, Washington, D. C.

Prize Essayists.

W. W. White (1897), Passed Assistant Engineer, U. S. N.

MEMBERS.

Able, A. H., Chief Engineer, U. S. N.....2034 Mt. Vernon street, Philadelphia, Pa.
Addicks, W. R., Chief Engineer Bay State, Boston and Brookline Gas Light Companies, 24 West street, Boston, Mass.
Aldrich, Wm. S., Professor Mechanical Engineering, and Director Department of Mechanic Arts, West Virginia University, Morgantown, W. Va.
Allderdice, W. H., Passed Assistant Engineer, U. S. N.
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81

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Building, Engineering and Mining Journal, Sun Building, Queen street, Melbourne, Australia.

Cassier's Magazine.....World Building, New York.

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Journal of the United States Artillery.....Fort Monroe, Va.

Literary Digest.....30 Lafayette Place, New York.

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Marine Journal.....24 State street, New York.
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"Seaboard,".....129 Broad street, New York.
Sibley Journal of Engineering.....Cornell University, Ithaca, N. Y.
Steamship, The.....2 Custom House Chambers, Leith, Scotland.
Stevens Indicator.....Stevens Institute, Hoboken, N. J.

Technology Quarterly.....Massachusetts Institute of Technology, Boston, Mass.

Western Society of Engineers.....1737 Monadnock Block, Chicago, Ills.

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Zeitschrift des Vereines Deutscher Ingenieure.....80 Wilhelmstrasse, Berlin.

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Record of American and Foreign Shipping .....37 William street, New York.
Reale Scuola Navale Superiore, il Signor Direttore della.....Genoa, Italy.

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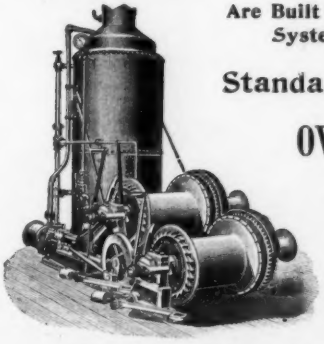

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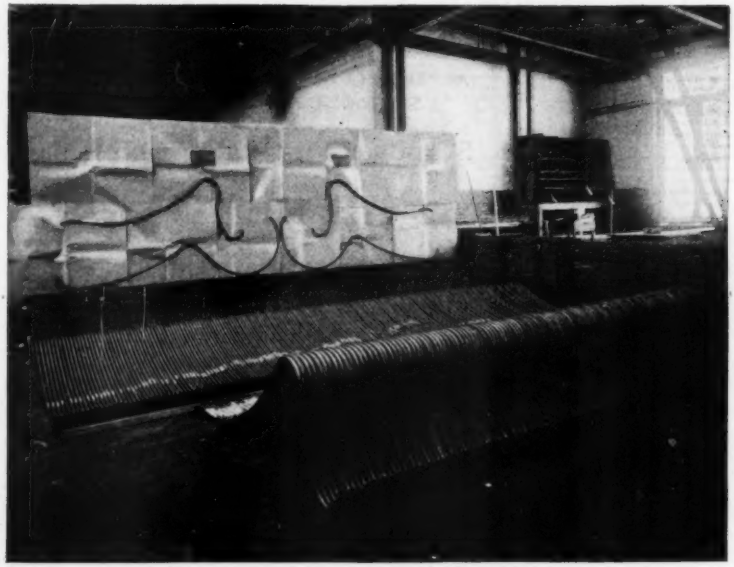

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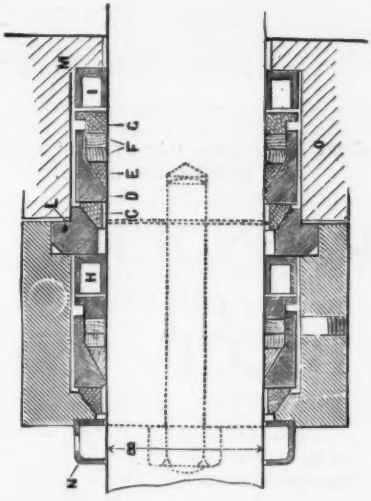

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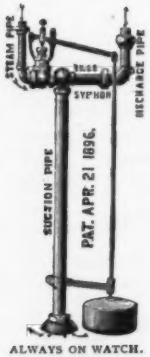

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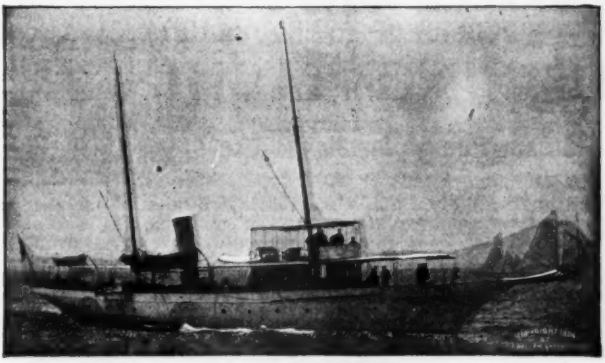

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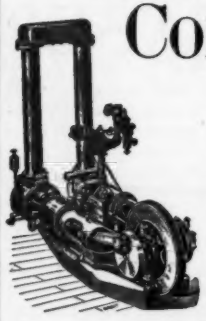

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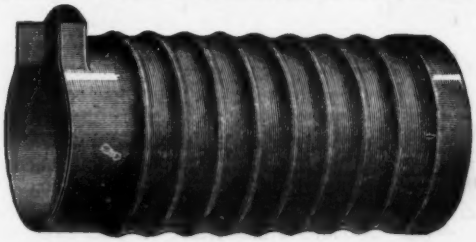

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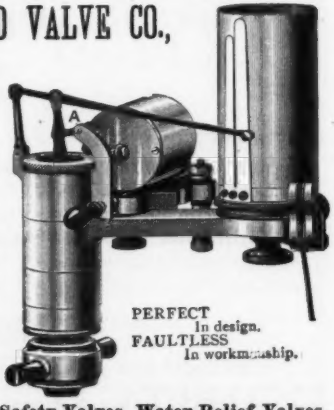

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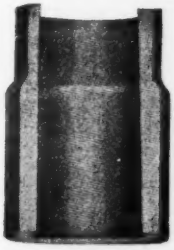
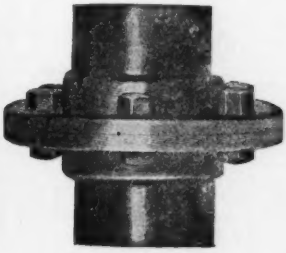
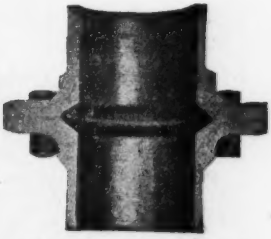


Upset Sectional View.



Upset and Flanged.



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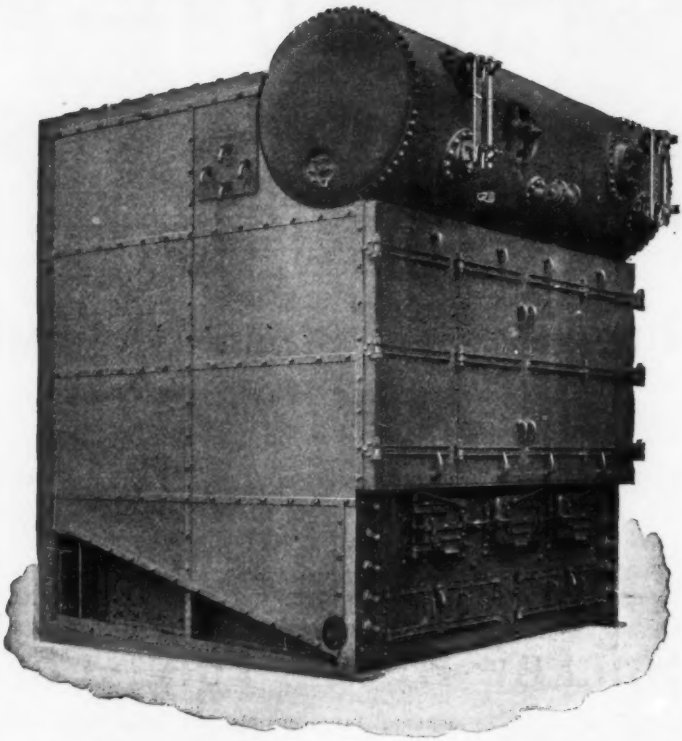

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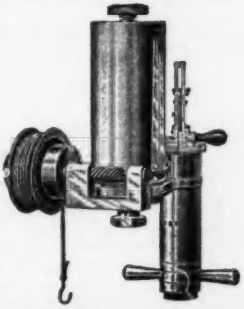

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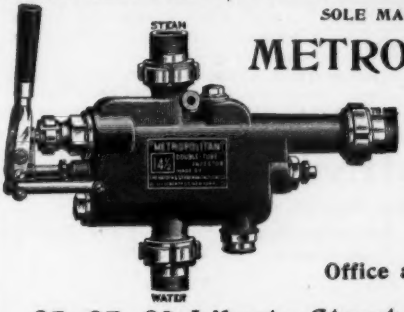

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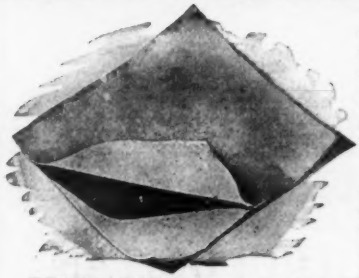

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